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THE OLDER WORKER

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WHILE it is true that modern war, the organized killing of our fellowmen and wholesale destruction of the products of human toil, can be waged most efficiently by men between the ages of 18 to 35, the industrial needs of this war have already demonstrated anew several important facts about the older industrial worker, facts well known, but forgotten or ignored in the plethora of peace-time manpower, and in the fog of a social philosophy according to which a life of leisure is heaven, and society must feed, clothe, and house all idle chicks whether or not these chicks can scratch. These facts are:

(1) The physiologic age of the worker is not synonymous with his chronologic age, owing to the individual variables in heredity, mode of living, accidents, and sequelae of disease.

(2) While most workers past fifty or sixty years of age have somewhat less physical strength and physical endurance, as well as some impairment of hearing and vision, these decreasing abilities may be compensated for in many forms of labor by the greater skill and experience and the decrease in youthful dissipation.

(3) By keeping in idleness older workers who can still perform useful labor we are not only wasting valuable human resources, but we are contributing to biologic parasitism in and degeneration of human society. For man is no exception to the biological law that existence without effort, without struggle, impairs the species.

(4) By forced idleness of the increasing army of older workers in our midst we are forging a dangerously weak link in that large fraction of society, whose experience, wisdom and relative unselfishness could guide those with less experience and wisdom. For when a person is shunted out of the dynamic current of life, courage and incentive are at low tide.

(5) One element in the philosophy of organized or union labor, namely, equal hourly wage for all workers in each special trade, must share part of the blame for the past practice of discarding the older worker by the management of industry. Even though all workers are not equal in skill and efficiency, and in spite of the fact that the practice of organized labor tends to gear the rate of all workers to the slowest in the group, there comes a day when the older worker, in many given tasks can not keep pace even with the slowest and least efficient younger comrades. Economic management calls for dismissal of the older worker at that point. If wage in proportion to performance was permitted, the older worker could taper off in industry, just as the young apprentice works himself gradually up in skill, performance, and

remuneration. From my knowledge of human nature another destructive effect on morale, efficiency, and joy of living results from the practice of gearing the most efficient to the rate of performance of the least efficient. On that plan the ablest worker will seldom, if ever, experience the joy of performance according to his superior ability, nor the growth in skill commensurate with his ability. This is not only a waste of precious human resources, but tends to make lives humdrum, lives that could be enriched by the daily challenge and joy of more and better performance. For the ablest worker to be geared to mediocrity, to do less than his best, is bad psychology for the ablest people, and is, so far as I can see, of little or no aid to the less able fellow citizen or to society. I speak not without experience. I was a farm hand, and a labor union carpenter before I became a college student, and an investigator and a teacher in the medical sciences.

Under more primitive and biologic conditions of human life, as in life on the farm and in agriculture in general, work and responsibility of children and youth have their normal biologic upward curve, as is the case among all wild animals who have to scratch for their living. Under similar conditions of life, as on the farm, men and women past fifty, sixty or seventy years also find their niche of productive work, happy in the knowledge that they still have a part in the stream of life. Biologically, man grows in understanding and physical and mental efficiency from birth up to twenty-three or thirty years of age, when there is a plateau of efficiency for some twenty years, health being present. Then the reversal of the youth curve sets in, the gradual impairment of the physical, and considerably later even of memory and of mental efficiency. A civilization, a social or an economic system, that discards men and women of fifty or sixty as no longer a link in the chain of human labor, as no longer productive physically and mentally, I say such a civilization, such social and economic systems, are thoroughly unbiologic, thoroughly wasteful and thoroughly cruel and inhuman to our fellowmen at the later decades of life. A man or a woman in modern industry, trained to do, and for twenty or thirty years having done only one such small thing as fitting a screw on a certain size nut for eight hours a day, may not be able to perform that mechanical feat at the sufficient rate when past fifty or sixty. But it is a terrible reflection on our education if such men and women can not do something else of value to society and to themselves. And it is certainly no indication of intelligent planning on the part of society if opportunities for such work are not afforded. In fact, tasks for which men and women past fifty, sixty and seventy are thoroughly capable lie all around us like mountains, but we do not see them. Social security for our aging population is all right in principle, but it should take the form of labor for which these people are capable and not the form of pay for doing nothing.

In industrial tasks calling for maximum performance of the entire machinery of the human body, the older worker by and large will be increasingly handicapped by the sequelae of accidents and disease, despite all efforts of accident prevention, and the growing knowledge and skill in medicine. Apart from, and in addition to these factors, what are the inevitable and unavoidable aging changes of man rendering him less fit, if not unfit to labor? When and how speedily do these aging changes come on in the individual? Do these aging changes or impairments constitute a bar from all useful labor? Can industry be

organized so as to make fair and adequate use of men and women handicapped by age alone? Is there no alternative to the relegation of men and women past fifty, sixty, or seventy years of age to the scrap-heap of idleness and the dole, to parasitism, and charity? All age changes come on gradually. Those body changes with age involving the strength and endurance of the skeletal neuromuscular mechanism, and with the senses of hearing and vision are probably the most significant for the industrial worker, but it must also be kept in mind that these systems are all dependent on a good diet, a good gut, good blood, good kidneys, and good lungs. The human body is a machine. Any weak link tends to impair all the other links. Some age impairments appear as early as the third decade. If all industrial labor were physically as exacting as prize fighting, marathon running, or professional football, nearly all workers would be retired at thirty-five years of age.

Progressive age changes not as yet shown to be due to specific diseases are: gradual tissue desiccation; gradual retardation of cell division, capacity of cell growth and tissue repair; gradual retardation in the rate of tissue oxidation (lowering of the B.M.R.); cellular atrophy, degeneration, increased cell pigmentation and fatty infiltration; gradual decrease in tissue elasticity and degenerative changes in the elastic connective tissue; decreased speed, strength and endurance of skeletal neuromuscular reactions; decreased strength of skeletal muscle; progressive degeneration and atrophy of the nervous system, impaired vision, hearing, attention, memory and mental endurance.

The Neuroskeletal System. The gradual slowing and weakening of reflexes and general body activity in the aging mammal is so obvious as to be well known both to physicians and laymen. Decreased functional capacity, both in the nervous tissues and the skeletal muscular tissue, seems to be at the base of this gradual decline. Actual atrophy of the Purkinje cells of the cerebellum has been described in the aged and, since this part of the nervous system is seriously concerned with skeletal muscle tone and coordination of skeletal muscle contractions, it may be a factor in the growing muscular weakness of old people, irrespective of the cause or causes of this atrophy in the cerebellum.

As regards the cerebrum of aged people, general atrophy has been described especially in the frontal and occipital lobes, and actual disappearance of cells in some of the layers of the cerebral cortex, as well as pigmentation and fat infiltration of the nerve cells and actual hyperplasia of the neuroglia cells. Similar degenerative changes with age occur in the spinal cord; that is, atrophic pigmentation, actual loss of cells and degeneration of the axones of many ventral horn cells. In the case of the brain, thickening of the meninges occurs with advancing age, but it is difficult to see how this in any way should interfere with nervous action or nervous function.

Recent investigations appear to demonstrate a very gradual but significant decrease in the myelinated fibers of the dorsal nerve roots with advancing age. This must be secondary to an atrophy and death of spinal ganglion cells and is probably the basis of the reduction in cutaneous and protopathic sensibility of aged people. The sense of pain seems to be the least affected by aging. In view of such evidence of atrophic and degenerative changes in the central and peripheral nervous system, irrespective of the primary cause or causes of these changes, it is not surprising that neuromuscular weakness, slowing of the reaction time, decreased capacity to learn, etc., are part and parcel of the physiol-

ogy of aging. The speed of learning seems indeed to decrease gradually in man from the fourth decade on. But this handicap of the aged is on the whole more than made up for in some individuals by their greater speed of correlation and evaluation of the new experience.

There is very little evidence of aging changes in smooth muscle, which seems on the whole to retain its normal histologic character into advanced old age. The diminished tone in smooth muscle, as may be seen in the blood vessels in the gut and the smooth muscles of the skin and other structures in old people, may be secondary to the impairment in the nervous system, indicated above. But not all the impairment of body motility with age can be ascribed to degenerative changes in the nervous system itself, because the striated skeletal muscle system shows fatty infiltration and brown atrophy with advancing age. The strength of the biceps at the sixth decade of life is only about fifty per cent. of that at the age of twenty-five to thirty. The trunk muscles decline in power somewhat slower. However, the recent investigation by Kubo (1938) reports little evidence of decrease in muscle strength and endurance in people that would ordinarily be called old, that is, people seventy to ninety years of age. This is just another illustration of the individual variations in the chronologic age appearance of the aging processes. There is some increase in connective tissue and elastic fibers in the skeletal muscle of old people and there is clear evidence of desiccation, that is, decrease in intracellular fluid. But in this respect the skeletal muscle of the aged falls in line with all the other tissues of the body.

Vision and Hearing. Because of the accessibility of the organs themselves and the availability of quantitative tests of functions, we have more accurate information regarding the aging changes in the physiology of the eye and the physiology of the ear than in most of the other systems of the human body. In the case of vision, there is a gradual decrease in visual acuity (central vision), a gradual narrowing of the visual field, as well as a slowing of the dark adaptation (peripheral vision), and a gradually higher threshold for light stimulation for man past the fourth decade. The narrowing of the visual field is probably due to the actual degeneration of the nerve cells (cones), starting in the periphery of the retina. We are not yet in a position to say whether these visual impairments occur independent of, or are secondary to, impaired retinal circulation. It is equally well known that the incidence of cataract increases with aging, irrespective of whether or not the tendency to cataract formation is hereditary. Arterial sclerosis would undoubtedly accelerate any such hereditary weakness, and so would certain faulty diets and certain endocrine and other metabolic disorders. The gradual decrease of the elasticity of the lens is another well-known and accurately measured phenomenon of aging man, with the exception that diminution in lens elasticity actually starts in childhood and practically all lens elasticity is lost before sixty years of age. The lens continues to grow at the periphery (vertex), and thus approaches closer and closer to the cornea with advancing years. At the same time, the material at the center of the lens becomes more dense. Both of these factors, and the lens swelling from increased water content, are responsible for the well-known phenomenon of so-called "second sight" of people sixty years of age and beyond. This lens change tends to counteract the presbyopia, or impairment of accommodation, due to the loss of lens elasticity. Other age changes that may contribute

to the gradual impairment of vision with age are diminished translucency of the cornea and of the vitreous humor. It need not be pointed out that the retina, being actually a lobe of the brain, is necessarily as seriously impaired by local vascular pathology as is any other part of the brain. However, because of the accessibility of the retinal vessels to direct inspection, we have probably earlier factual information regarding such pathology in the retina than we have in most of the other deep organs of the body.

Hearing. From the age of about twenty on, there is a gradual loss of acuity to all tones, but the loss of sensitivity is greater to the high tones. This deterioration of hearing is somewhat greater in the male, but the degree of retrogression is not predictable in chronologic age, as some people at eighty have no greater auditory impairment than other normal people at fifty. This impairment of auditory acuity is present even when tested by bone conduction. The cause for this decline in auditory acuity appears to be a gradual but distinct atrophy of the nerve cells in the basal coil of the cochlea. But anemia, due to incipient arterial sclerosis, may also be a factor, since in experimental anoxia the perception of the high tones goes out first.

In the light of all these facts, one would expect that intellectual capacity should decline parallel with neuromuscular strength and endurance. According to all existing evidence, this is not the case. This exception is probably due to the significant role of experience, especially in the case of complex intellectual problems.

The diet of the older worker. While we do not know what may be the optimum diet for optimum efficiency for any age, we do know enough to say with certainty that the older worker will keep most fit by eating enough good food to avoid underweight, and avoid eating so much food that he or she becomes obese. Life insurance statistics show clearly that marked underweight, as well as marked obesity, shorten the life span. Common experience demonstrates that both impair physical endurance and performance. It is not difficult to understand why ingestion of food to the point of obesity is injurious to people with reduced factors of safety in the matter of insulin, pancreas, sugar and fat metabolism. Such dietary excesses damage by overwork already impaired mechanisms. But in the absence of diabetes, actual or incipient, why does obesity, maintained for years, initiate or aggravate cardiovascular, renal, and other disorders that shorten the life span? While the answer to these questions is being sought by experiments and accurate observation on mice and men, prevention of obesity in all workers past thirty appears to be a prophylactic imperative, a *must.*

From time to time financially fortunate and humane fellow citizens provide funds for "old peoples homes." I hope that some financially fortunate, humane, and farsighted fellow citizens will soon provide the National Research Council with a fund of $1,000,000 to be used towards learning *what is the optimum diet for old people:* old workers in industry, as well as those in old peoples homes. It should be quite clear to all informed people that normal aging strikes no man with suddenness of an acute disease. We are not worth 100 per cent., industrially, today, and worth zero tomorrow on our sixty-fifth or seventieth birthday. We grow old and inefficient, just as we grow up and efficient, over the years. We have discovered that useful work can be performed by people with disabilities more serious than those of normal aging, such as the blind, the deaf, the mute,

people minus a hand, an arm, a leg, or both legs. We readily admit that useful work suitable to the gradually aging worker is less readily provided in industry than on the farm. But it can be done, it has been done, it is being done even in industry. Such an experiment by the Dodge Division of the General Motors Corporation in Detroit is described in some detail in Forbes' Magazine for November, 1942 by Don Wharton. This experiment seems more significant as it was well under way (1934) before the present war, and hence, not carried financially by the present billions of federal war appropriations. The ninety-nine workers in the "Old Man's Division" of the Dodge plant average sixty-six years in age and some of them are past eighty. In the farflung Ford industries a more extensive and commendable employment of people handicapped by age, and by the sequelae of disease and accidents, appears to be an established and a feasible practice (*Saturday Evening Post,* Feb. 6, p. 16, 1943). Says Edsel Ford: "No man is hopeless or helpless as long as he has the will to do and his fellow men will give him a helping hand. Courage is not a matter of age or physical conditions." But the fact that all of these workers receive the same pay (93 cents an hour) makes me think that the department is not run on a strict economic basis, that the excess costs, if any, are charged against all the workers in that industry, or added in the price of the product, a practice not uncommon, and possibly justified in the better morale of the older worker. The general formula relating work to remuneration seems simple:

A. The younger worker: Physical strength and endurance growing, but not at adult par; skill and experience growing, but not at adult par—less than adult performance and pay.

B. The adult worker: Strength and endurance at maximum; experience and skill near or at maximum—maximum performance and pay.

C. The older worker: Physical strength and endurance receding, experience and skill at par—generally less than adult performance and therefore less pay.

I never could understand, I do not now understand, how industry as such can practice charity. Monies so devoted must, by necessity be deducted from wages, salaries and dividends to stockholders, or else the cost added to the cost of the product, in which case the charity is given, to be sure, without their knowledge by the consumers of the industry's product. Some day man may achieve sufficient stoicism to face with equanimity the fact that charity and doles are for the children and the sick, not for the aged, unless incapacitated by age.

If what I so far said squares with facts, reason, and wisdom, as well as with our conception of justice, we might expect educational institutions to be ahead of industry in the elimination of waste of the older workers. But this is not so. In general, there is full salary and duties of college and university men up to sixty-five and seventy, and then abrupt unemployment, on assumed total incapacity. Two factors are probably mainly responsible for this waste: (1) the younger generation in a hurry, and (2) the older generation so ignorant of biology that it can not see the justice of reduced pay for reduced capacity and performance. One of our large state universities recently recalled as dean of its graduate school a man now seventy-seven, whom the same university retired from that position nearly ten years ago. It is not probable that this university dean is to-day more capable than he was ten years ago. It seems more probable that this university wasted a valuable human resource for ten years.

According to the United States Census, the number of people past sixty-five years of age in our population has in-

creased during the last ninety years from 2.6 per cent. to 6.8 per cent. If this trend continues, and I think this is assured by more of science and the better art in medicine, fifty years hence about fifteen out of every hundred people will be over sixty-five years old. I think we can add that, by and large, this army of older people fifty years hence will be even better qualified for useful work than are the people of the same age to-day. Thanks to more science and better art in to-day's medicine our larger aged army of 1940 is less decrepit than was our smaller army of sixty-five-year-olds a hundred years ago. It is sheer waste, bad biology, and gross injustice all around to feed, house, and clothe this army of idleness. Old age pension is not the answer. The dole is not the answer. The only answer is useful work for pay, plus sickness and accident insurance. When aging has rendered us incapacitated for useful work, we are truly sick, and sickness insurance should meet our needs. I think I am discussing important principles, not arguing about names, not fighting windmills. Still, it must be admitted that at sixty-eight some people fail to recognize their own delusions. I think that useful work is a privilege and a blessing, not a curse. It is also a biologic and social duty as long as we can carry on. Because the probability of less elastic arteries and less cardiac reserves, not to mention less strength in the skeletal muscles, the worker past sixty should, as a rule, not be put at tasks calling for the physical power that a worker, age twenty to forty, may deliver with safety. Moderation in all things, and a thorough medical check up twice a year will aid us in keeping fit to carry on. There is the prevailing view that quitting useful work before the infirmities of old age and specific disease compel it, hastens the age decline and brings on death sooner. It is difficult to check this view by adequate controls. So far as I know, this view is based on conspicuous instances, forgetting the exceptions. But to the extent that idleness decreases the zest of living, and unhappiness and depressing mental states actually impair some of our body machinery, it may be true; especially if the pleasure from good food is still strong, for in that case injurious over-eating is likely to become the rule. I dream of a to-morrow when our millions of men and women, well past the chronologic three score will say, with Albert J. McCray, age seventy-one, now running a drill press at a Douglas Aircraft plant, "I'd rather have a job than a pension any time" (*Time*, Dec. 14, 1942) for that spirit helps to keep the older worker young, and aids in making America stronger.

ARTIFICIAL RADIOACTIVITY AND THE COMPLETION OF THE PERIODIC SYSTEM OF THE ELEMENTS

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EVERY time that some fundamental advance has been made in one of the physical sciences, it has almost immediately brought fruits in neighboring fields, revealing that close interdependence between various branches of the sciences which is one of their most characteristic features, even in times of ever-increasing specialization.

The interaction between physics and chemistry has always been particularly strong, and one of the forms it has taken is that of new chemical discoveries being brought forward by the application of some newly developed physical method of investigation to chemical problems. Thus, we may consider the most fundamental and classical problem, that of knowing all the elements. The history of this quest is a most fascinating one and in the early days of scientific chemistry could almost be identified with the history of chemistry itself.[1]

When the impetus of the newly developed scientific analytical chemistry had spent itself around the middle of the nineteenth century, about sixty elements had been discovered and most of the minerals offered by nature had gone through the mills of chemical analysis. At the same time the genius of Mendeleef (1869) was laying the foundation for a systematic interpretation of the discoveries made and gave hints as to the directions in which the search could be prosecuted. However, it was clear that the missing elements must be either very rare in nature or, for some reason, very difficult to isolate (rare earths), so that new and more powerful tools were necessary to make substantial progress. It happened that in 1860 this tool was most luckily found by Bunsen and Kirchoff in the application to chemical problems of the newly developed spectroscope; and the fruits were copious and immediate (discovery of rubidium and cesium first, later many other elements). The spectroscope became a most useful tool for the further progress of the knowledge of the elements, allowing us to find them even on the sun, when no terrestrial sources were known (Helium, Lockyer). However, after a while even the optical spectroscope had exhausted its almost miraculous powers and the utmost refinements of old and well-known techniques had reached their limits, after the discovery of the noble gases and the partial unraveling of the complex of the rare earths. But Mendeleef's table showed merciless white spaces still to be filled by the scientist's ingenuity. Certainly if it had been known how rare are elements like polonium on the earth's crust, the quest would have been given up as hopeless.

It was the investigation of a strange physical phenomenon that, around the turn of the century, gave the most sensitive analytical method known to date, and at the same time started the greatest revolution in the foundations of chemistry since the time of Lavoisier, Dalton and Avogadro. Some of the "eternal and immutable atoms" of classical chemistry were shown to undergo spontaneous transformations, uncontrollable by man and dominated by the law of chance. By catching them in the intermediate states

[1] See *e.g.*, M. Weeks, "The Discovery of the Elements."

of their evolution, first the Curies, and later Rutherford, Soddy, Hahn and others, were able to add to the known ones many other chemical species, the most notable being radium and polonium. Their ultrasensitive methods are, however, able to reveal only "living" atoms, or, more scientifically, unstable atoms, because they are based upon the detection of the radiations given out by the atoms at the moment of transformation. Unstable atoms with minor exceptions are found in nature only among the heaviest, most complex atoms and hence the discoveries made with the help of natural radioactivity were only of elements heavier than lead.

The laws of radioactive decay assign to each atom of a given kind a constant, finite probability of exploding in a given time interval (decay constant). This probability may be very small as in uranium (5×10^{-18} per second), or very high as in UX_2 (1.0×10^{-2} per second). The reciprocal of the decay constant is called mean life. However, if a substance B originates through any number of transformations from a substance A having a smaller decay constant, after having waited a sufficient length of time, a situation arises in which, in a mixture of the two, the number of A atoms exploding per unit time is equal to that of the B atoms exploding per unit time. Such a condition is called radioactive equilibrium. The number of explosions in A and B per unit time, if the two substances are in radioactive equilibrium, is the same, but the numbers of atoms of A and B present may be tremendously different: as a matter of fact, the ratio of the numbers of A atoms to B atoms is equal to the reciprocal of the ratio of the decay constants. It is easy to calculate, for example, that for one gram of uranium we have in radioactive equilibrium with it 5.0×10^{-16} gram of UX_2. This amount is extremely minute, but if we use for detecting the substance a device that counts not the atoms, but the *exploding atoms*, 5×10^{-16} gram of UX_2 will be just as easy to detect as one gram of uranium. From these considerations it follows that the radioactive methods may have a tremendous sensitivity compared with any other one, provided the substance to be investigated has a large decay constant.

It is also clear that a short-lived substance may be present in nature only if it is in radioactive equilibrium with one that has a very long life; so that a large fraction of the latter's atoms, present at the formation of the earth, has had the possibility of surviving. This means that the smallest mean life admissible is in the order of 10^9 years. Shorter lived substances, if not in equilibrium with a long-life parent substance, have practically disappeared. The ordinary stable elements are the final fossils of all these atomic evolutionary processes. They were apparently dead forever until man found, a few years ago, a new way of resuscitating them and starting some new transformations in them, certainly less rich than the natural ones, but nevertheless of great scientific interest.

Natural radioactivity thus helped to fill the gaps in the periodic system among the heaviest elements, but some of the blanks shown by Mendeleef's table were among the light elements; and besides these, there was a region of the periodic table, that of the rare earths, where even that most powerful heuristic tool could not make unequivocal predictions even about the number of missing elements. Again a new fundamental discovery in physics gave the key to the enigma. In 1912, Moseley, using the newly discovered x-ray spectroscope, found a regularity in the x-ray spectra of the elements which allowed him to read the atomic number, or the ordinal number of the element in the periodic system, directly from the spectrum. It was then easy to find out which elements were still missing. The empty places had the numbers 43, 61, 72, 75, 85, 87 and 91. These numbers are

simply the positive charge of the "sun" in the planetary atom, assuming as unit charge the charge of the electron, and each completely determines the chemical properties of an atomic species.

Elements 91, protoactinium, and 87, ekacesium, are among the very heavy ones and were found in nature in the radioactive families by Hahn and Miss Perey respectively. Elements 72 (hafnium) and 75 (rhenium) are also found in nature and are stable; their detection and isolation was achieved by Hevesy and Coster (72) and by I. and W. Noddack (75) in the twenties. Especially in the case of element 72, the discovery was guided by the great progress that had been made in the theoretical unraveling of the atoms, thus making possible a prediction of its properties, on which the semi-empirical table of Mendeleef gave uncertain information. Its name hafnium, from Copenhagen, was chosen in homage to that center of research where Bohr and his associates played such a large part in developing the modern atomic physics. The chief analytical tool in both investigations was the x-ray spectroscope.

After these discoveries, the only elements left were 43, 61, 85, and an intensive quest has been made for them in *natural* products. Many times success has been announced, but subsequent investigations have always failed to confirm the discoveries claimed. The probable reason for this situation is that according to our present knowledge of the atomic nucleus such elements are unstable and could be found in nature only in the relatively unlikely case that they should possess an extremely long half life. The prediction of the instability of such nuclei is based upon a large amount of empirical material and a plausible theoretical interpretation of the same, and they are the only elements deemed unstable by the rules of Mattauch.[2]

[2] See *e.g.*, H. Jensen, *Naturwiss.*, 26: 381, 1938.

Hence until the discovery of artificial nuclear transmutation it was hopeless, although it was not known to be so, to look for the missing elements in the natural ores, their only terrestrial source. The situation changed entirely with the advent of artificial transmutation, because it then became possible to *manufacture* the element one wanted to study. A vast amount of experimental material on artificial radioactivity which has been rapidly accumulated, systematized, and given a theoretical interpretation between 1934 and the present, has made it easy to predict what type of transmutation occurs under a given kind of bombardment. Generally the prediction is not unique, but only a few alternatives are left. Thus by slow neutron bombardment one almost always has the transmutation into a heavier isotope of the same atomic number; by deuteron bombardment the atomic number is changed by +1, −1, or 0; by alpha particle bombardment the atomic number is increased by one or two units, etc.

If, for example, we bombard element 42, molybdenum, with deuterons, we can reasonably expect that some isotopes of element 43 will be found; and if they are radioactive we will be able to detect even the extremely minute amounts formed by this method. The question arises, however, as to how we are going to be sure that the radioactivity observed is due to element 43 and not to some other substance, for example, a radioactive isotope of molybdenum, formed in the bombardment. The answer is very easy if we have a stable isotope of the newly produced substance, because then if we add a little of it to our radioactive substance and perform the usual procedures of chemical analysis, we shall observe that the radioactivity sticks together quantitatively with the stable isotope of the radioactive substance, and no chemical operations can ever separate it. To be sure, this is only a negative proof because, strictly speaking, one can not carry out all pos-

sible chemical reactions with a given substance, and one may miss just the important ones. That this can actually happen is borne out by the almost incredible tale of the transuranic elements, and especially of element 93 where, by the incorrect application of these principles, many mistakes were made.[3] On the other hand if two substances can be chemically separated by analytical methods they certainly are not isotopic

The situation is more complicated in the case of a new element, and especially of the artificial ones, because the amounts available are then so extremely minute as to be invisible and unweighable. The detection occurs through the radioactivity, but it is impossible to carry on most of the chemical operations in the ordinary way. Thus, for example, precipitation and filtration of the pure substance are well nigh impossible. Also, serious doubts may be entertained as to whether the behavior of a substance at such extreme dilutions is the same as for ordinary quantities. This whole complex of problems is not new: as a matter of fact, it arose in the early days of radioactivity, and a whole branch of chemistry, radioactive chemistry, is devoted to its solution.

We now have a whole series of semi-empirical rules by which we can reasonably predict, from the behavior of a radioactive isotope present only in extremely small amounts, the behavior of a "weighable" amount of the same substance If, for example, the radioactivity is precipitated in an acid solution by hydrogen sulphide, together with copper, lead, and any other element that is precipitated by hydrogen sulphide, it is very probable that the radioactive substance will form an insoluble sulphide. Again if we can distill the radioactive substance under certain conditions we can also be reasonably sure that a large amount of it would be volatile under the same conditions. But other properties like the color, electric conductivity, specific gravity, etc., can not be measured with such minute amounts.

One thus sees that a study of the radiochemical properties of the remaining undiscovered elements 43, 61 and 85 might be expected to give interesting and valuable information.

Element 43 was prepared in the Berkeley cyclotron by bombarding molybdenum with deuterons or neutrons. It was identified and its radiochemical properties were investigated by Perrier and the writer in 1937. Its general behavior is very similar to that of its heavier homologue rhenium, but substantially different from that of its lighter homologue manganese. The separation from molybdenum, the parent element, is very easy and can be done in a few minutes. A detailed discussion of its chemical properties would exceed the limits of this article and for this we must refer to the original papers.[4] Although the quantities of element 43 so far prepared are too small for spectroscopic detection, it may be mentioned that the K lines of its x-ray spectrum have been observed although of course not in the usual way by exciting the spectrum on the anticathode of an x-ray tube. Their spontaneous emission occurring as a consequence of the transition from an upper to a lower excitation state of the nucleus gives detectable lines.[5] Element 43 can also be produced by alpha-particle bombardment of columbium and is separated from that element by sublimation in a stream of oxygen. By this method it can be deposited on an inert support as an invisible radioactive layer.

[3] To mention only one of the latest, the writer established correctly (*Phys. Rev.*, 55: 1104, 1939) several chemical properties of a certain substance, which properties he wrongly interpreted as showing that it was a rare earth until McMillan and Abelson (*Phys. Rev.*, 57: 1185, 1940) proved conclusively that it was an isotope of element 93.

[4] C. Perrier and E. Segrè, *Jour. Chem. Phys.*, 5: 715, 1937; 7: 155, 1939.

[5] G. T. Seaborg, E. Segrè, *Phys. Rev.*, 55: 808, 1939. See also P. Abelson, *Phys. Rev.*, 56: 1, 1939.

In the case of element 61 the study of the chemical properties is somewhat superfluous because, since it is a rare earth, it is quite certain that its chemical properties will be extremely close to the properties of the other rare earths, and on the other hand no simple method of separation from them is to be expected. Several types of bombardments could give radioactive isotopes of element 61, but the interpretation of the results is not completely certain. There are good indications that praseodymium bombarded with alpha particles[6] gives an isotope of element 61. More work will be needed before a final conclusion can be reached.

Element 85 is a heavier homologue of iodine and has been prepared by the bombardment of bismuth with the high energy (32 Mev) alpha particles of the 60-inch Berkeley cyclotron.[7] Its chemical properties are notably different from the properties of iodine in so far as it shows marked metallic characteristics close to the properties of bismuth or polonium. For example, it is precipitated by hydrogen sulphide in acid solution, it is not precipitated like the halogenides by silver salts, and it is electroplated on several metals. It is also easily sublimed from the metallic bismuth and in this way it can be collected pure as an invisible radioactive layer.

The radioactive transformations involved in the decay of element 85 are also quite interesting, involving the capture of a K electron from the inner shell of electrons followed by the emission of an alpha-particle from the nucleus. The substance formed by the K capture of element 85 was already known in natural radioactivity as Ac C′ and is a member of the actinium family.

The above-mentioned studies on elements 43 and 85 give a clear picture of most of the chemical analytical properties of these elements and can be used for a search for natural isotopes in two ways. First, they make possible predictions on the geochemical behavior of such elements and thus indicate the minerals most likely to contain them. Secondly, by using the artificial elements as tracers, they permit a continuous check on the enrichment processes.

From what is known of element 43, it seems very likely that it would be usually associated with rhenium. But the fact that many hundreds of pounds of rhenium have been isolated from various ores without any conclusive demonstration of the existence of element 43 seems to show that it does not exist in nature; this is as predicted by the systematics of nuclei.

The status of element 61 is similar to that of element 43, but although the great similarity of element 61 with the other rare earths makes the geochemical predictions very reliable, it is much more difficult to reach definite conclusions as to its existence from chemical evidence than for element 43.

The case of element 85 finally is considerably different because its properties differ substantially from these of its homologues. The failure of the searches performed in the past, for example, by Buch Andersen,[8] are inconclusive because we now know that the chemical operations performed would not have led to an enrichment of the substance looked for, but rather would have eliminated it. The Mattauch rules are also inapplicable in a region where all the elements are radioactive and it is not impossible that some isotope of element 85 may be found in nature.

To complete a discussion of the search for new elements, one should also include the transuranic elements. Their story, however, transcends the limits of this article, which deals with the completion, not the extension, of the periodic system.

[6] J. D. Kurbatov, D. C. MacDonald, M. L. Pool, L. L. Quill, *Phys. Rev.*, 61: 106, 1942. C. S. Wu, E. Segrè, *Phys. Rev.*, 61: 203, 1942.

[7] D. Corson, R. MacKenzie, E. Segrè, *Phys. Rev.*, 58: 672, 1940.

[8] E. Buch Andersen, *K. Danske, Videnskab Selskab.*, 16: 5, 1938.

QUININE: THE STORY OF CINCHONA

By NORMAN TAYLOR

DIRECTOR, CINCHONA PRODUCTS INSTITUTE, NEW YORK

If you happened to be a stranger in Missouri in the 1830's and stopped at Arrow Rock you might well think they were in the midst of a revival, for each evening the bells of the Methodist Church were rung rather vigorously. But it was not a call to prayer—merely a reminder for every one to take Dr Sappington's pills. You would know why if you stayed through the sleepy, sluggish summer, for malaria stalked the land and the good doctor's pills were mostly quinine. He was one of the first and by far the most famous medico in the Mississippi Valley to use this remedy for malaria.

The disease was a curse to Arrow Rock, which nestled along the banks of the meandering and highly malarious Missouri River. And Dr John Sappington, in his attempts to stamp out the disease, became, for a slightly different reason, almost as colorful as his direct descendant, Ginger Rogers. He is sometimes smirched as a quack, but several biographies, and notably his inclusion in the revered "Dictionary of American Biography" would seem to disprove it. Actually, more than any physician of his time, he knew that the treatment of malaria was not then what it should be and that the disease, unchecked, was blighting not only his own people but the waves of pioneers, so many of whom died along that swampy road to Eldorado.

The charge of quackery came as the result of a mistake. Sappington knew, as the "Autocrat of the Breakfast Table" wrote later, that "quinine . . . was among the sovereign and invaluable boons to humanity." Its use in malaria had followed the isolation of the alkaloid in 1820, and the establishment of the first quinine factory in the world at Philadelphia in 1823.

To Philadelphia, then, Sappington sent his son to buy a certain number of ounces of the precious remedy, then worth about three dollars an ounce. The transaction completed, Dr Sappington found that the youth had bought in *pounds* instead of ounces and the old gentleman was very nearly ruined. But he did possess a great stock of quinine. Convinced of its value in malaria, he invented "Dr Sappington's Anti-fever Pills" and soon had pill peddlers all over the Mississippi Valley. In those days Methodist Church bells were just as good as the radio, and salesmanship, plus a little professional jealously from Philadelphia, made him an anathema to the current purists on medical ethics.

His true position has much to do with the story of quinine. Many years later, when the smoke of controversy had cleared away, Dr Robert J Terry, a medical historian, had this to say of Sappington:

> The political enemies of Thomas Jefferson protested that in the Louisiana Purchase the United States acquired a swamp unfit for human habitation. The Mississippi Valley is to-day the home of millions. Who will say that the introduction and distribution of quinine in the early days was not a factor of great significance in establishing homes and settlements in a region infested with malaria? The control of malaria in the great valley required years of persistent effort under the hardships of frontier life and was not spectacular, was it less of a contribution to civilization than to-day's triumphs of sanitation for which we are justly proud?

Malaria is still the curse of all regions with warm summers and sluggish, mos-

quito-ridden water. Seventeen of our southern states still suffer from it and in the tropics it is far worse. The latest figures, which probably are too conservative, add up to the astounding world total of 800 million cases and over 3 million deaths annually. India has always been the worst sufferer.

To-day there hangs at Arrow Rock a portrait of Dr. Sappington by George Caleb Bingham, and rightly so, for he sensed the importance of malaria, and

DR. JOHN SAPPINGTON

OF ARROW ROCK, MISSOURI, A PIONEER IN THE USE OF QUININE IN THE MISSISSIPPI VALLEY. (FROM A PORTRAIT BY GEORGE CALEB BINGHAM, NOW IN THE OLD TAVERN IN ARROW ROCK.)

his work in that sleepy Missouri town presaged the world significance of quinine in the treatment and prophylaxis of that disease. He had many medical detractors, especially those who bled already depleted patients, almost to death. But he fought on and deserves at least a niche in the medical hall of fame.

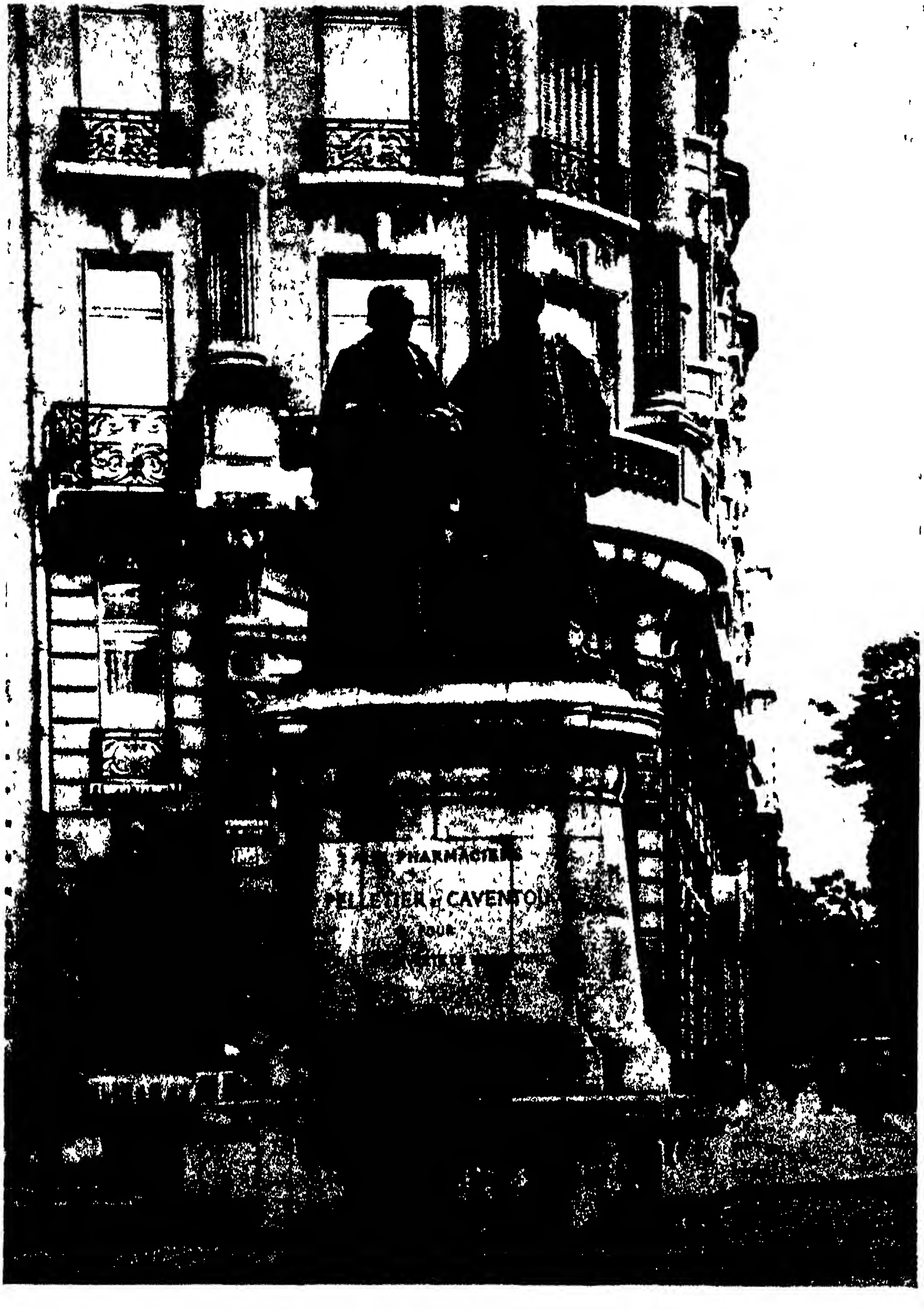
What malaria is, and what quinine does to it, goes far back of the isolation of the alkaloid by Pelletier and Caventou in a laboratory in Paris on September 11, 1820. For that discovery a statue of them was erected on the Boulevard St. Michel to commemorate an event that affects every one to-day—for upon quinine victory is largely dependent.

For quinine, pronounced qui-neen′ everywhere except here, and universally called kwy′-nine in the United States, or quin′-in or even qui-nine′ in Virginia, is one of the few real specifics known to medicine. The scholarly "Webster's" in defining the word "specific" says "exerting a peculiar influence over any part of the body; preventing or curing disease by a peculiar adaptation; as quinine is a *specific* medicine in malaria " (Italics theirs.)

But no one knows why Hundreds of millions of malaria patients have been cured with it, and a huge amount of research has been accomplished on it, but we do not yet know how it works if, indeed, it ever works directly upon the microscopic plasmodium which is the cause of malaria. Perhaps no other drug has ever been so widely used with such complete ignorance of the mechanism of its action.

Its effects, however, are direct and unquestioned. They are perhaps best reflected in the world demand for it. Prescribed in grains, it is literally produced in tons. Just before the present war the world consumption was about 722 tons annually. Since the war, and before the invasion of Java, where most of the quinine trees grow, production for the year 1941 was 1017 tons No tropical campaign can be run without it and our far-sighted government began to lay by a stock of it, long before Pearl Harbor.

Uncle Sam has been accused of bungling the rubber situation both before and since Pearl Harbor. But no one can accuse him of quinine bungling. The old gentleman has a longer memory than some of his detractors. He knew how



STATUE OF THE DISCOVERERS OF QUININE

WHO ISOLATED THE ALKALOID IN A LABORATORY IN PARIS ON SEPTEMBER 11, 1820. THE STATUE WAS ERECTED ON THE BOULEVARD ST. MICHEL IN 1900 BY POPULAR SUBSCRIPTION.

General Gorgas made the Panama Canal possible, and why malaria would have stopped canal digging if Gorgas hadn't given nearly forty thousand doses of quinine per day—until he'd controlled mosquito breeding. Our government, or rather a handful of army and navy doctors, remembered that story and dreaded the malaria toll in possible tropical campaigns. So they began the accumulation of the largest stockpile of quinine ever gathered in this country. The amount is a military secret, and its whereabouts even more so.

It seems almost axiomatic that this competence of our army and navy doctors had to be matched by those who produced quinine. With ever so much foresight and a fat purse, Uncle Sam could still have been licked if there had been any futility about growing the tree that produces quinine or extracting the alkaloid from its bark. Why there was neither goes back to the slopes of the Andes well over three hundred years ago.

Where It Started

From Colombia to Bolivia on the Amazonian slopes of the Andes there are many species of shrubs and trees of the genus *Cinchona*. All are first cousin to coffee and the ipecac, or in simpler terms, *Cinchona* belongs to the Rubiaceae. They are handsome plants with opposite leaves and pale pink or white flowers in lilac-like clusters. The bark of some of them is the only source of quinine. As in most tropical forests, they do not occur in pure stands, notwithstanding newspaper statements to the contrary.

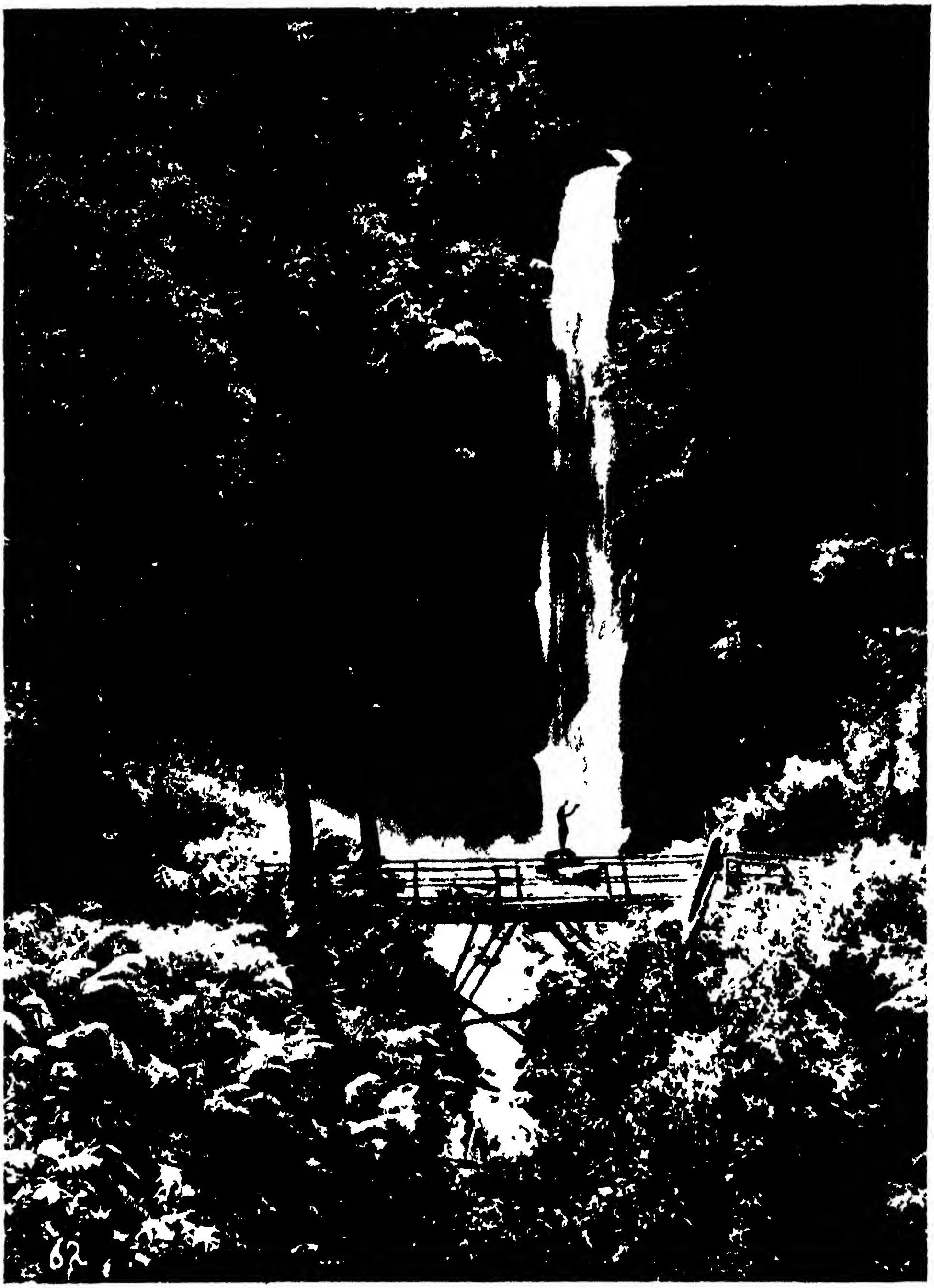
Who first found that the bark of a few of these cinchona trees was good for ague, as malaria is often called, will probably never be known. Gracilasso de la Vega, a son of one of the conquerors of Peru, who married the daughter of an Inca noble, does not mention it in his "Royal Commentaries on the Incas." They had a word for it, *quina*, from which is derived *quinine*, but there is no evidence that the Incas knew of the value of cinchona bark. About a century later the Jesuit priests at Lima do seem to have known of its value, hence its old name of Jesuit's bark, and later, Peruvian bark.

Somewhere about 1630 there was hatched the most colorful, romantic, and wholly untrue legend about cinchona, which this article, nor a dozen better ones, will scarcely eradicate. The story goes that the Countess of Chinchon, the wife of the Spanish viceroy, was stricken with malaria in Lima in 1630 and snatched from the verge of the grave by the timely intervention of adequate potions of the bark of quina. So grateful was the lady that the ground-up bark was promptly christened Countess' Powder and she is credited with introducing it to malaria-stricken Spain and Italy. It is a pretty legend, swallowed by Linnaeus, who named the trees *Cinchona** in her honor, and by everyone else until November, 1941.

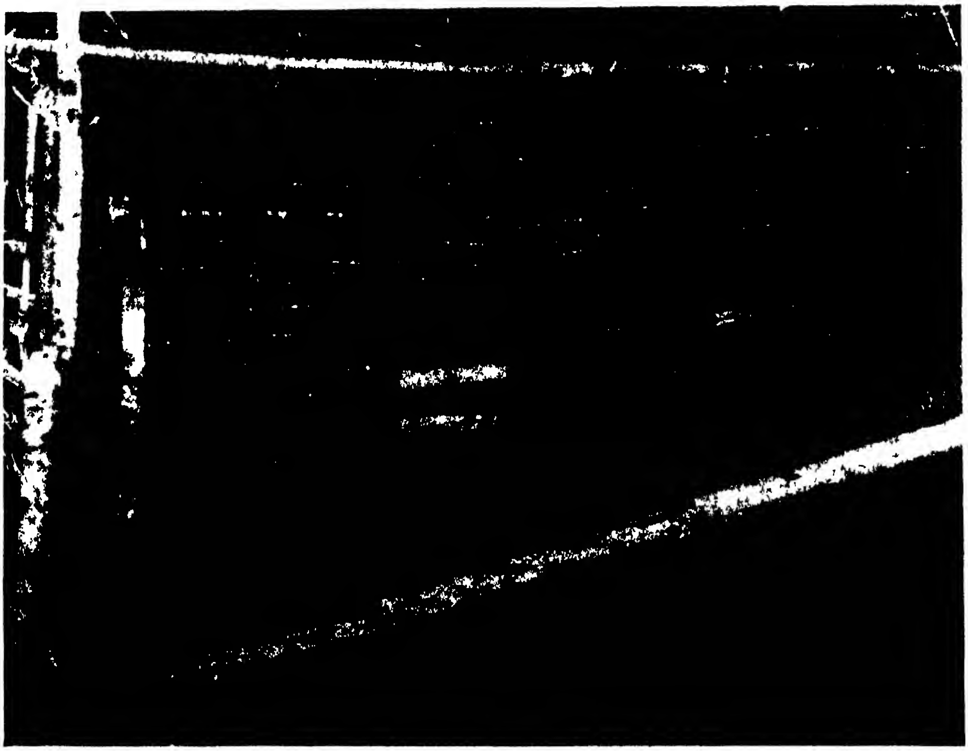
The three-hundred year old canard was finally exploded by A. W. Haggis in the *Bulletin of the History of Medicine* for October and November, 1941, published at Johns Hopkins University. This proves that the countess never had malaria, that her husband often did, but that even for the viceroy there was no cure by cinchona bark, for no one at Lima then knew anything about it. Nor did the countess ever take it to Europe for she died on her way home, as is proved by the Archives of Franciscan Friars at Lima, who wrote:

> By these presents let it be known unto you how, on the 14th January of this year 1641, in the City of Carthagena of the Continent of this Kingdom, Our Lord gathered unto Himself, Donna Francisca Henriquez de Ribera, Countess of Chinchon, and a patroness of our Holy religion.

* Linnaeus dropped an "h" in naming *Cinchona* for the Countess of Chinchon. According to the rules of botanical nomenclature his mistake must be perpetuated, notwithstanding the subsequent confusion in spelling.



PREANGER REGENCY IN WESTERN JAVA
WHERE CLIMATE, ELEVATION AND SOILS ARE MOST FAVORABLE FOR CINCHONA CULTURE.



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A WELL-GERMINATED SEED BED OF CINCHONA SEEDLINGS

MANAGEMENT OF SEEDLINGS, TO PREVENT "DAMPING OFF," IS NOT EASY IN WARM HUMID REGIONS.

This would seem to dispose of the Countess of Chinchon legend but tells us nothing as to who first took cinchona bark to Europe, nor when. It is first mentioned in European medical literature by a Belgian, Herman van der Heyden, in his "Discours et advis sur les flus de ventre douloureux," published at Antwerp in 1643. Its value must have been known then, and there the early history of *cinchona* must rest, awaiting further research.

Its history for the next two hundred years is marked by futility, extravagance, and towards the middle of last century, by a rapidly dwindling supply of the bark For it should not be forgotten that for nearly two centuries infusions and extracts of the bark had been in world-wide use for malaria Long before quinine was finally isolated as a powerful drug, patients were given bitter extracts of cinchona bark which, besides quinine, contains three other alkaloids—cinchonine, cinchonidine, and quinidine—which are also used in malaria.

So tremendous was the trade in bark that England and Holland became alarmed about the middle of the last century because each had highly malarious colonies and both feared that exhaustion of the dwindling bark supplies would spell disaster. Holland in the 1850's and England during our Civil War, sent out elaborately equipped expeditions to the Andes to secure seeds, plants, or any other material suitable for starting plantations in India and Java Both expeditions failed because *Cinchona* contains

many worthless species and both the Dutch and the English secured the wrong kinds. The effects were disastrous for the English whose plantations in India have never paid, although quinine from them *must* be produced even at a loss, because of the huge population and the worst malaria incidence in the world

There then entered the most fantastic episode in the long history of quinine. Completely unheralded, with no scientific training, no elaborate expedition, but a good deal of common sense, there lived at Puño, Peru, an Englishman by name Charles Ledger While the British Expedition under Sir Clements Markham was scouring the Andes for *Cinchona*, Ledger went on about his alpaca trading and gathered cinchona bark as he had for years. He rather fancied some barks from the headwaters of the Marmoré River, in nearby Bolivia, and ultimately secured, through a servant, fourteen pounds of seed from these trees. While Ledger knew that the bark from which they came was high in quinine, he little guessed that this collection was to change the whole future of the quinine industry.

He sent the lot to his brother in London with instructions to offer them for sale to the government for their plantations in India. The British declined. His brother then went to Holland and offered the shipment to the Netherlands government for their Java plantations The prudent and thrifty Dutch bought one pound, for one hundred francs, with more to be paid if the seed produced trees

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BARK DRYING IN THE SUN

PRELIMINARY PREVENTION OF MILDEW IS ACCOMPLISHED BY DRYING THE BARK IN THESE FRAMES, AFTER WHICH IT IS OVEN DRIED

high in quinine Soon after, they paid him a total of about a hundred dollars (£24) for the pound of seed

The balance of the seed was sold by Ledger's brother to a British Indian planter, who went completely sour on his purchase and traded it for other varieties with the government cinchona plantations in India The British Indian officials planted the Ledger seed but few ever germinated and these all died

Meanwhile the single remaining pound of Ledger seed arrived in Java in December, 1865 It was planted at the Government Cinchona Plantation under the direction of K W van Gorkom, without any notion of what was to follow. Some of the seed had spoiled, but twenty thousand germinated and twelve thousand seedlings were set out the following year.

To four men, van Gorkom, J. C. B. Moens, J E de Vry, and M Kerbosch, is due the final success of cinchona culture in Java. For forty years they persisted in their experiments in the face of bitter criticism from the people and at times from the government of the Netherlands Indies The Government Cinchona Experimental Station at Tjinjiroean was ridiculed as "the expensive hobby" No private planters could be coaxed to grow cinchona. But to-day there are over a hundred private planters up in the mountains of Java, and until the island fell to the Japanese, the descendants of those magical trees from Ledger seed produced nearly all the quinine in the world They were most appropriately christened, in proper Latin, *Cinchona ledgeriana*

It is an oft told tale, and far too long to repeat here, of just how all this was

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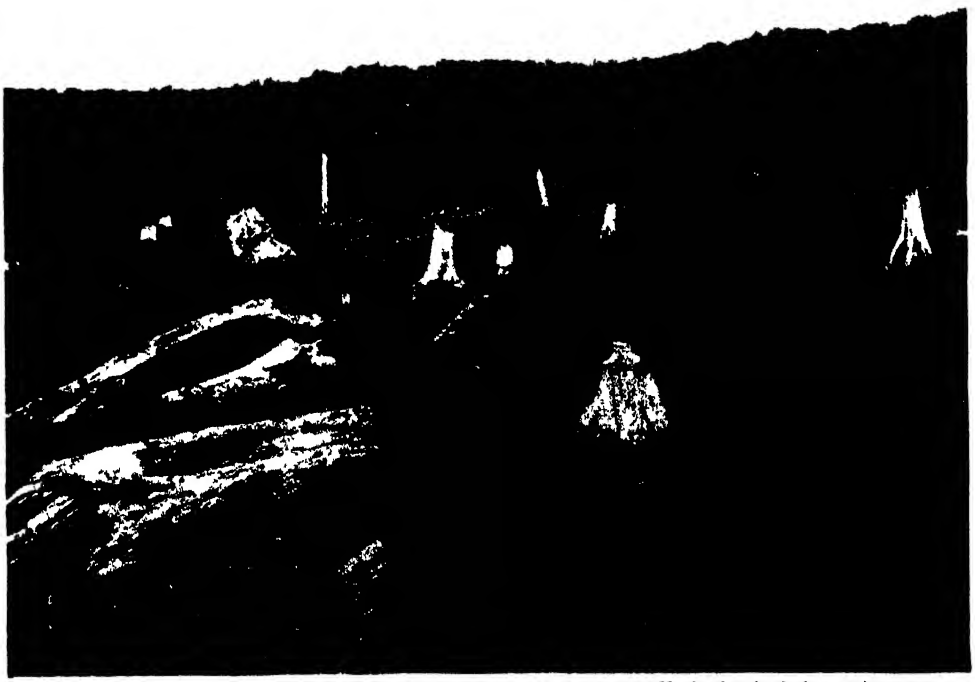
CRITICAL STAGES OF CINCHONA CULTURE REQUIRE EXPERT CARE

accomplished. When it is remembered that *Cinchona* is as likely to spontaneously hybridize as blackberries, the ultimate standardization of a pure line with high quinine content seems all but miraculous It is still more so because it antedated any knowledge of the Mendelian ratio which was rediscovered by another Dutchman, Hugo de Vries, at Amsterdam, in 1900.

In addition to controlled hybridization, of which the Dutch did a good deal, there was an extraordinary coordination of horticultural practice, soil science, chemistry, and forest succession And this meant long-range planning, for the bark is gathered only by the destruction of the trees The Dutch still carry on their experiments on cinchona culture, to maintain their excellent record, or to improve it The present head of the Netherlands Indies Cinchona Experiment Station is Mr M A van Roggen

Any American horticulturist or forester of repute would be foolish to state that this extraordinary Dutch perfection of cinchona culture could not to-day be duplicated So far it never has, however, in spite of the fact that the Netherlands Indies Government has freely given or sold seeds to those who have tried Failures or equivocal results, both by foreign governments and private planters are recorded from India, Eritrea, St Helena. Formosa, Indo-China, Belgian Congo, Reunion, the Caucasus, Madagascar, Hawaii, Tanganyika, Queensland, Burma, Uganda, Cameroons, Jamaica, and even in California It has also been tried, somewhat more successfully, in the Philippines

More recently the U S Department of Agriculture has germinated thousands of cinchona seedlings at Beltsville, Maryland, under glass They are then shipped to climatically favorable places in tropi-



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NURSERY SEEDLINGS READY FOR THEIR FINAL PLANTING

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WOMEN FIELD WORKERS WEAR BATIK SARONGS

THE MEN WEAR PRINTED COTTON JACKETS (KABAJAS) AS THEY WEED A JAVANESE PLANTATION OF YOUNG CINCHONA TREES

cal America, with the hope that quinine production will ultimately come back to those Andean slopes from which it was taken The enterprise at Beltsville is under the able management of Mr. B Y Morrison, who is chief of the Division of Plant Exploration and Introduction, of the Department of Agriculture. He has few illusions as to the long and difficult years ahead, although experimental plantings have been made in several countries, notably Puerto Rico, Costa Rica and Guatemala

For the immediate future there seems only a slim chance of quantity production anywhere in the New World, because the main harvest of bark comes only after fifteen to twenty years, and there are many pitfalls. Perhaps American enterprise can do in ten years what it took the Dutch forty to accomplish, but even then the United States and the cooperating Latin American governments are starting almost from scratch. Guatemala, at the moment, holds the most promise, although it is climatically less favorable than the original home of *Cinchona*.

The Situation To-day

The commercial extraction of quinine is possible, in normal times, only where the bark contains 6 per cent. or more of quinine sulfate (which is *quinine*, to most of us) The success of the Java planters is based upon the fact that their trees never yield less than this, and often considerably more.

Most wild cinchona from South America is lucky if it contains as much as 2½–3 per cent. of quinine. All the huge commercial plantations in Ceylon were

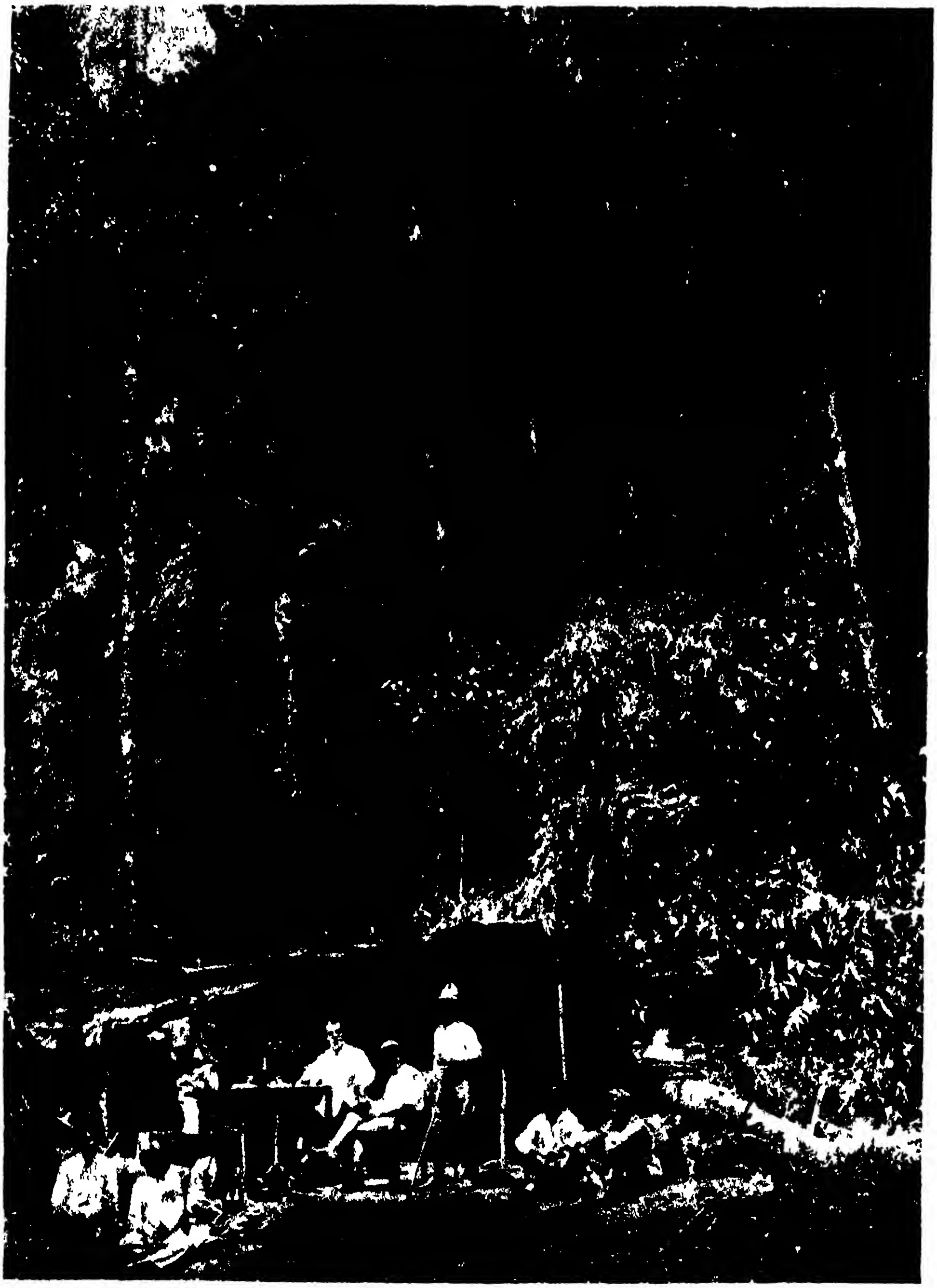
automatically put out of business at the turn of the century for precisely this reason Java bark came into full scale production about that time and both Ceylon and the wild bark trade in South America practically folded up.

Nearly all the world supply of quinine is, or was, until March, 1942, produced from Java bark This was extracted partly by the largest quinine factory in existence at Bandoeng, Java, and the rest in a handful of European factories, or by the only two important quinine manufacturers in the United States

The combined production of these was ample for the world's needs, and even the vastly increased war demands for quinine were so well met that not only our government, as noted previously, but most large-scale pharmaceutical and proprietary establishments were able to build up stocks of quinine to anticipate the ultimate stoppage of shipments from Java

Notwithstanding this foresight, something like panic seized the country when Java fell in March, 1942 Quinine, hitherto rarely mentioned in the news-

SOME TREES OF *CINCHONA LEDGERIANA*
AT THE NETHERLANDS INDIES GOVERNMENT CINCHONA ESTATE, TJINJIROEAN, JAVA.



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A GROUP OF HIGHLY SKILLED PROSPECTORS

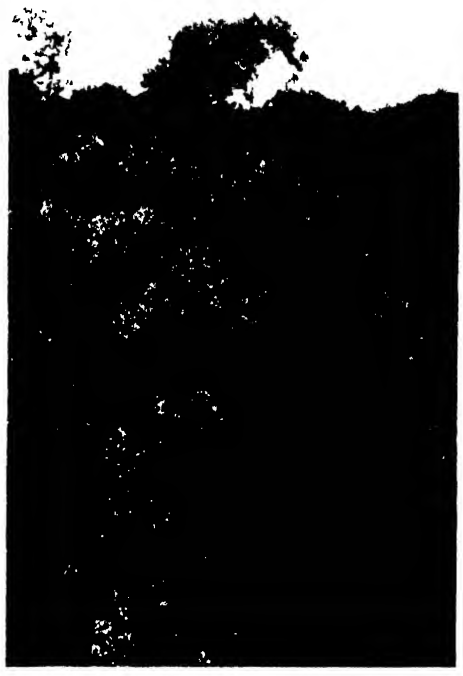
WHEN NEW CINCHONA PLANTATIONS ARE PROJECTED, MEN SUCH AS THESE CHOOSE THE SITES.

papers, yielded, through our clipping services, thousands of articles charging "shortage," "hoarding," "price-fixing," "government incompetence," "speculation," "monopoly," and a dozen other figments. Such was the public outcry that some congressmen, who should have known better, and a few self-appointed "experts" demanded that something should be done about quinine. Despite the fact that their ignorance of the real situation very nearly matched their clamor, Uncle Sam, of the long memory, became a bit perturbed He finally silenced them by issuing three extremely wise orders

The first was to limit quinine to its use in malaria This worked an undeniable hardship upon those who had used it for years for colds and influenza But we are at war, and no soldier should be denied quinine because of its diversion elsewhere Malaria, in wartime, is more important than the common cold, even if 35 per cent of all cold remedies do contain quinine

The second was the manufacture of totaquina This had never before been made in the United States, its use having been dictated by the low-yielding cinchona barks of India, Malaya, and the Philippines The total alkaloids of these inferior barks were extracted and enough quinine added to bring the mixture up to therapeutic effectiveness The name totaquina (*i e.*, the total alkaloids of cinchona bark) and the formula for it were invented by the League of Nations Malaria Commission It is a refinement of the old cinchona febrifuge, long used in India, and more effective than it Today totaquina, which has been admitted to the new edition of the U S Pharmacopoeia, is made by at least three American manufacturers who rely upon the low-grade South and Central American barks, hitherto of little or no interest These, with negligible exceptions, are worth next to nothing so far as the commercial extraction of quinine is concerned. but they can be used to make totaquina which costs less than quinine, is considered a little less effective, and hence given in somewhat larger doses

The third directive of our government controls all importations of cinchona bark from Tropical America, fixes a price for it based upon its alkaloidal content, and also fixes the price at which totaquina may be sold Both orders stopped ruinous bidding for cinchona bark and useless gouging of the public for totaquina



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LILAC LIKE CLUSTERS
OF FLOWERS OF *Cinchona ledgeriana.*

In a democracy like ours it would be delirium of optimism to expect all this to have been accomplished without some faltering There has been much of it, as between the several war-time agencies interested in quinine. But the plain fact is inescapable that Washington, in spite of all criticism, has safeguarded our

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CINCHONA BARK GATHERERS

quinine supplies during the emergency and provided for the production of a reasonable war-time substitute for it in totaquina

Totaquina, like quinine, must be used, for the duration, only for malaria That is, and always has been, the chief use for quinine and the other alkaloids of cinchona But some other uses are important Besides the common cold and influenza, already mentioned, quinine has been used in minor surgery as an anesthetic, as a test for goiter, in Meniere's disease, for varicose veins, and in obstetrics for its reputed action on the muscles of the uterus The *Quinine Formulary* also lists other uses for it, and the use of quinidine in auricular fibrillation. So important is the latter that the government permits its use for this purpose, because several thousand people would die of this heart affection without a daily maintenance dose of quinidine.

Other Remedies

In a disease so world-wide as malaria it would be most surprising if many other remedies had not been put forward to challenge the undisputed position of first, cinchona, and then, quinine, during the past three hundred years. There have, in fact, been many. They range from the Civil War use of Georgia bark (*Pinckneya pubens*), the dogwood (*Cornus florida*), the bark of an ash tree in China, the emu apple of Australia, the "quinine" bark of California (*Garrya*), to the numerous old-wives' remedies, now long forgotten. Other, and more modern methods of chemotherapy also have their adherents. Among the latter are derivatives of the sulfa drugs, arsenic, epinephrine, and some others originally found in the laboratory of the I. G Farbenindustrie in Germany. Of the latter, two have been admitted to the new edition of the "U. S. Pharmacopoeia" under the

names "quinacrine" and "pamaquine," which for some time had been known under their trade names of "atabrine" and "plasmochin."

No one has ever yet found a real synthetic quinine, all the others being possible substitutes for it Their position in the treatment of malaria to-day is perhaps best appraised in the report of the League of Nations Malaria Commission In a book of 558 pages entitled "The Treatment of Malaria" (Geneva, December, 1937) they contrast the current malarial remedies, based on carefully controlled clinical tests on many thousands of patients from all over the world Their summary·

> Among those drugs *quinine* [italics theirs] still ranks first in current practise, by reason of its clinical effectiveness and almost complete absence of toxicity, coupled with the widespread knowledge of its use and dosage.

For many centuries malaria was supposed to come from the noxious evaporation of swamps, hence its name, malaria, (bad air) Nobel prize winner Sir Ronald Ross was the first to prove that mosquitoes were the only carriers of the plasmodium that causes it. But many simple people still follow Shakespeare, who wrote of malaria in *Julius Caesar*, warning Brutus not

> To dare the vile contagion of the night

That was written before cinchona bark

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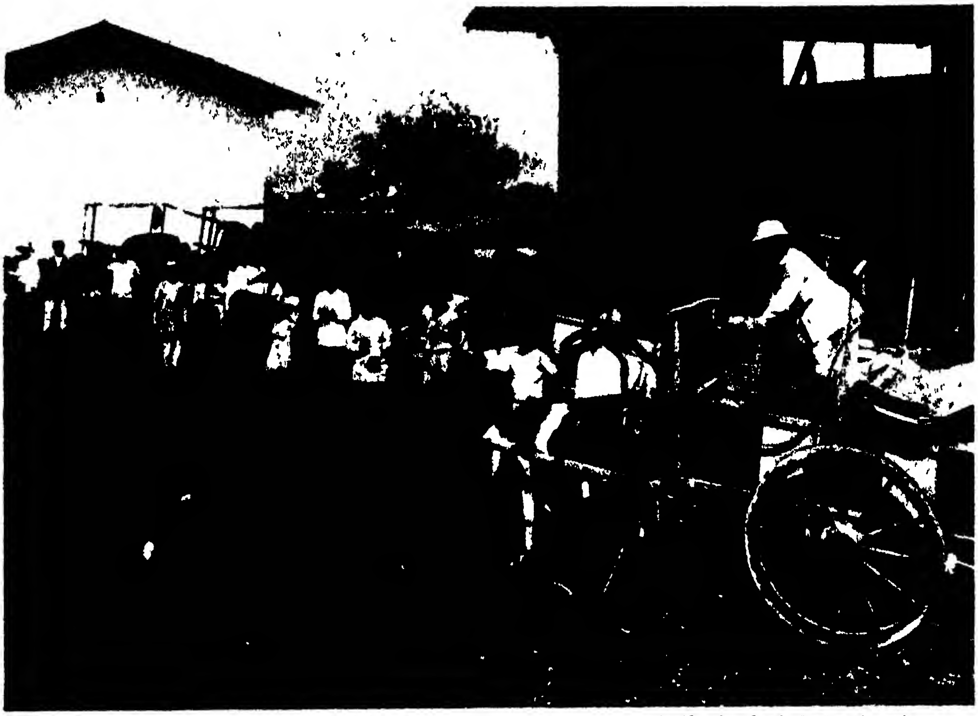
CINCHONA BARK OVEN IN WHICH THE MOISTURE IS DRIVEN OFF

THE OVEN PICTURED ABOVE IS LOCATED IN BANDOENG, JAVA.



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JAVANESE CINCHONA BARK GROUND AND BALED FOR SHIPMENT

reached Europe Fifty years later the bark became the subject of incredible stories, of court intrigue, of ecclesiastical bickering, and a bitter battle among the medicos.

But it survived all this, and finally, through the isolation of quinine became one of medicine's few specifics. Why it did so suggests the not impossible notion that perhaps it was worth it

EDITORIAL NOTE The author has not undertaken to present the recent developments of the use of synthetic drugs in the treatment of malaria Further information on the cause, treatment and prevention of malaria can be obtained from a volume recently published by the American Association for the Advancement of Science "A Symposium on Human Malaria, with Special Reference to North America and the Caribbean Region," where, in an article by Dr. Hans Molitor, it is stated that "The introduction of synthetic compounds with antimalarial properties, equal or superior to those of quinine, is one of the greatest triumphs of systematic chemotherapeutic research and the first real advancement in the field of antimalarial therapy since the introduction of quinine" The reader is also referred to Volume I of the 1943 edition of "Stitt's Diagnosis, Prevention and Treatment of Tropical Diseases" by Colonel Richard P Strong, director of tropical medicine for the Medical Corps of the U S Army and emeritus professor of tropical medicine of the Harvard Medical School Basing his statements upon the report of the Malaria Commission of the League of Nations (1937) Dr Strong writes "In ordinary cases of *P vivax* infection, the Commission states it is almost immaterial whether quinine or atebrin be used for treatment. For mass treatment where little or no medical supervision is possible, the cinchona alkaloids are the most suitable Medical supervision is necessary if atebrin be used The administration of quinine preparations, and especially of synthetic drugs, by the parenteral route, should only be resorted to in special circumstances or cases.

"In regard to the conclusions of this Commission that the action of atebrin on relapses 'is slightly more effective than that of quinine, especially in the case of benign tertian and of certain strains of malignant tertian,' there is some difference of opinion"—W. C

CULTURAL INFLUENCES OF PENNSYLVANIA'S MOUNTAIN GAPS

I. EARLY ADAPTATIONS OF NATURAL ROUTES

By Dr. BRADFORD WILLARD

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WATER and wind gaps of the Appalachian Mountains, particularly in Pennsylvania, have played a significant role in the development of transportation, in the settlement of the "back country," and occasionally they have figured in military operations The story of the peopling of our eastern seaboard by Europeans is elementary United States history From scattered, feeble settlements, the population grew and pushed inland Early adventurers and settlers of the Middle and Eastern Colonies discovered presently that they were separated from the western interior of the continent by a mountain wall that appeared all but impassable But, as exploration added familiarity with the country, routes were found across the topographic barrier Only the Hudson and Mohawk valleys in New York offered a complete, low-grade, though circuitous, passage to the west Yet, other lines of migration were discovered farther to the south It is to those in Pennsylvania that our attention will be chiefly turned, where routes lay along river valleys and through mountain gaps In Pennsylvania certain local conditions also influenced their utilization more than in other states

The geologist and the physiographer have studied the gaps and recorded the tale of how they originated and what their characteristics are. Pennsylvania is situated in a region of physiographic variety Parts of it lie within the Appalachian Plateaus, Applachian Valley, Appalachian Mountains, Piedmont and Coastal Plain Provinces Crossing the State from the east-central region in Lehigh and Northampton counties in a southwesterly direction to the south-central border in Franklin County is the Appalachian Valley Section of the Appalachian Valley Province It is bounded on the southeast, partly by the Triassic Lowland Section of the Piedmont, partly by portions of the Appalachian Mountains Province The rest of southeastern Pennsylvania to the Delaware and including the Triassic Lowland Section is grouped with the Piedmont Province except for a small area of Atlantic Coastal Plain Province bordering the Delaware River Northwest of the Appalachian Valley Section comes the broad area of parallel or concentrically curving mountains and valleys known as the Ridge and Valley Section of the Appalachian Valley Province Forming the western and northwestern border and rising as a steep escarpment facing this last division is the Allegheny Mountain Section of the Appalachian Plateaus Province This region passes westward into the plateaus of the western part of the State It is with the Ridge and Valley section that we are primarily concerned in the present discussion. Along its river valleys with their many water gaps, transportation routes have been opened It is therefore in order to discuss briefly the origin of the mountain gaps. As to their utilization, it is the intention in this account to emphasize only those in Kittatinny Mountain, which is the first or southeasternmost range of the Valley and Ridge Section.

Origin of the Gaps

In order to understand the nature and origin of the gaps through the Appalachian Mountains of Pennsylvania, it it necessary to review the factors concerned with their making There are two kinds of gaps included in this discussion, *water gaps*, those through which streams are now flowing, and *wind gaps*, which today are occupied by no streams of water

The stratified rocks which today form our mountains and through which the water and wind gaps have been cut are old Drop back in geologic time some 300,000,000 years or more to the Silurian period. From rocks of this age or younger, practically all of our prominent ridges and valleys have been sculptured In those ancient years, geographic conditions in what we now call eastern North America were hardly suggestive of today's familiar features East of the present mountains extend the piedmont and coastal plain and the submarine continental shelf. In Middle Paleozoic times there existed in this region and even beyond to the east a landmass. Perhaps continental in size, it is the *Appalachia* of the geologists and paleogeographers. Along its western edge, which corresponded roughly to the present eastern border of the Appalachian Mountains, ran a sea coast Although a western coast, it opened upon anything but the Pacific Ocean as known today It was the eastern shore of an inland sea which lapped over part of the interior of the continent In its shallow water, limy muds accumulated far from shore Simultaneously, along that Paleozoic coast of Appalachia, sands and muds and pebble beds were laid down where beaches fringed the land Waves eroded as they pounded the coast; tides and currents contributed their part in spreading sediments Rivers and streams flowing off the land brought seaward their loads to be dropped as deltas or swept away into deeper water Most of the

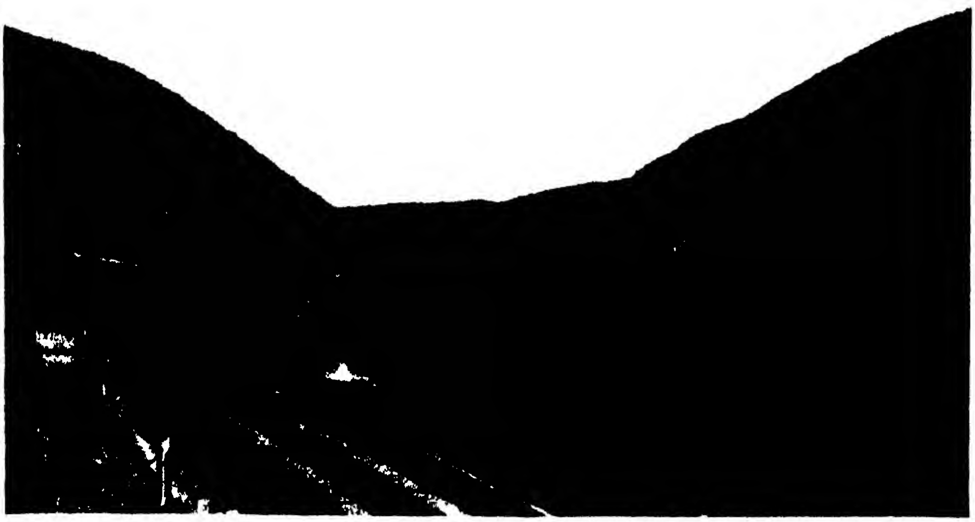

FIG. 1 DELAWARE WATER GAP FROM THE SOUTH

AMERICAN WATER GAPS HAVE LONG BEEN USED BY RAILROADS AND OTHER MEANS OF TRANSPORTATION IN PASSING THROUGH THE MOUNTAINS THE ROUTES WHICH HAVE DEVELOPED IN THIS WAY ARE NOW MARKED BY INDUSTRIAL CENTERS.

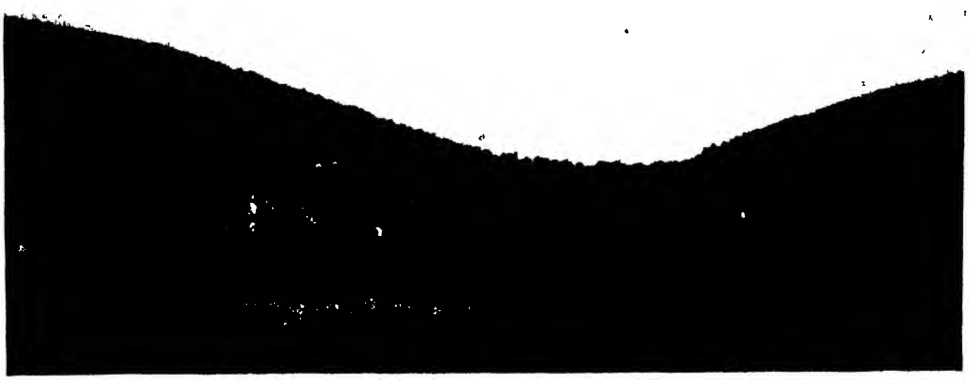

FIG 2 VIEW OF WIND GAP FROM THE SOUTH IN NORTHAMPTON COUNTY
THE WIND GAPS, TOO HIGH FOR CANAL OCCUPATION, HAVE SOMETIMES BEEN USED BY RAILROADS. MODERN HIGHWAYS MAKE EXTENSIVE USE OF THEM THROUGH THIS PARTICULAR GAP MARCHED GENERAL SULLIVAN'S ARMY ALONG THE ROUTE NOW OCCUPIED BY STATE HIGHWAY NO 12

sediments fell to the bottom near shore Many show signs of deposition in shallow water Yet they are in their total many thousands of feet thick

Despite the amount of mud, sand, gravel and precipitates which the sea acquired, it failed to fill up for a very long time For some millions of years, even as layer upon layer of sediments spread over the bottom, that bottom, instead of building up to sea level and changing to land, subsided beneath its load The load, greatest near shore, lessened westward in proportion to thinning of beds away from the coast In time, a long, narrow lens or wedge of sediments evolved over the subsiding ocean bottom along the western coast of Appalachia. Because the bottom continued to sink, roughly in proportion to the amount of

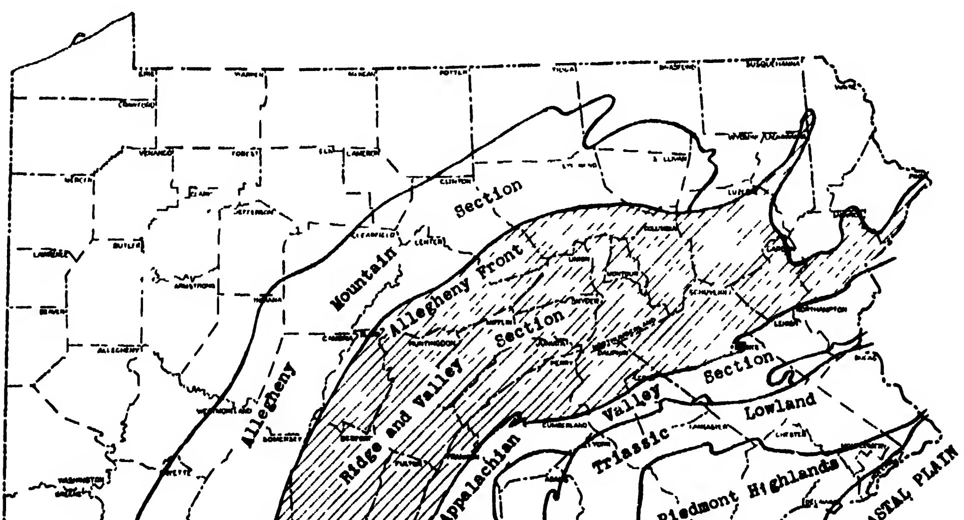

FIG. 3. PHYSIOGRAPHIC SUBDIVISIONS IN PENNSYLVANIA
THE RIDGE AND VALLEY SECTION IS SHADED (PARTLY AFTER ASHLEY.)

sediment added, thousands of feet of strata accumulated They were piled up in the sea, but sea level remained constant over the subsiding region Such a region, sinking under the weight of sediments, is geologically dubbed a *geosyncline* or syncline of deposition The process which adjusts the earth's crust to keep pace with the growing load of layers, is complicated Its sponsors are the geophysicists who refer to it as *isostatic adjustment*.

Here in the Appalachian geosyncline, originated the rocks of our present-day landscape The old seaway engendered our mountains! Examine rock cuts along mountain-penetrating highways There are layers of gravel, sand, mud, limy beds turned to solid rock Some beds are filled with fossil sea shells Others perhaps are marked by tracks of ancient, crawling creatures More may enclose

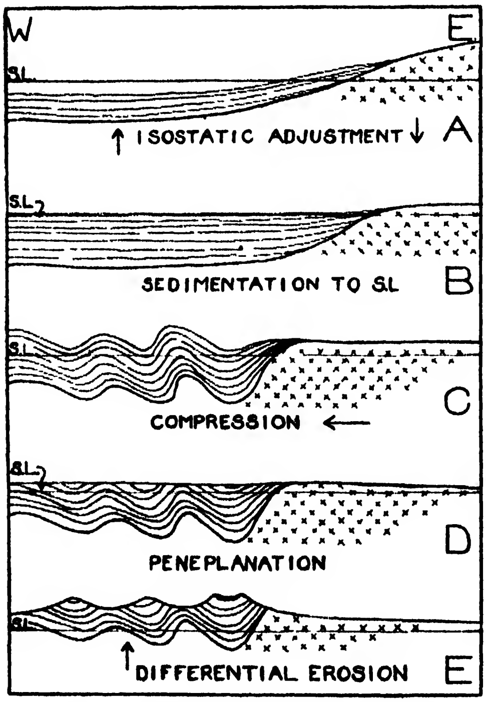

FIG. 4. CROSS SECTION DIAGRAMS
SHOWING THE SUCCESSIVE STEPS FROM GEOSYNCLINAL DEPOSITION TO DEVELOPMENT OF THE PRESENT APPALACHIAN MOUNTAINS.

shreds and mats of an antique vegetable world Besides these fossils, there are also such false fossils as ripple marks formed where shallow water currents stirred the mud and sand of rocks-to-be Cracks show where the mud dried and shrank at low tide,—and perhaps one finds the little dimples produced by rain drops as a short, quick shower passed over mud exposed to the Silurian or Devonian clouds Is clearer evidence needed to confirm the origin of these rocks?

Once flat layers on the sea bottom, these beds no longer lie flat Many are folded and distorted far from their original positions. Others are broken and crushed over their neighbors Some time after these strata were deposited and had consolidated to hard rock, something happened to crumple them Eventually, or perhaps during folding, the whole area was lifted bodily up, out of the sea Not merely did it become dry land, actually it rose to mountain heights from the area where once the waters of the inland sea had rippled.

The *modus operandi* of mountain building is obscure The results are evident The changes since the time of the geosyncline to the present may have been something as follows

The process called isostatic adjustment slowed down and finally ceased altogether As adjustment stopped, the sea bottom no longer dropped out as deposition loaded it The sea filled up, a change evidenced in the rock succession. Whereas the earlier beds of the geosynclinal prism were formed in the sea, and carry traces of marine life, the latest ones formed in fresh water or on land and contain land plants, whose residuum today is coal. Even as the geosyncline was filled, Appalachia was so worn down that the supply of sediments from that source ended The filling of the geosyncline to form dry land and the final degradation of Appalachia were synchronous events. One of those

major earth paroxysms called a geologic revolution followed

During such a revolutionary interval, compressive forces fold and break the rocks of the earth's crust. In the *Appalachian Revolution* which affected the eastern part of the United States, the ancient land mass, Appalachia, was pushed bodily westward or northwestward. Squeezed vise-like were the geosynclinal sediments in its path As snow is shoved before the advancing shovel edge or plow, so did the rocks pile up Simultaneously, or immediately following the interval of compression, the region of the geosyncline was uplifted, that of Appalachia subsided The relative altitudes of the two areas reversed themselves The erstwhile sea-floored geosyncline became a region of folded rocks raised as the ancestral Appalachian Mountains The old land to the east went down, perhaps not at once, wholly below sea level, but low enough so that now fresh-water, later on marine, sediments began to accumulate on its surface

Examine a little more carefully these rocks rescued from the bed of the ancient sea and raised in folded mountain chains They vary among themselves both in relative thickness of the individual strata and in the physical and chemical features of the beds, that is, their lithology Some layers or whole formations are soluble limestone, others soft shale In contrast are those of hard and insoluble sandstone and beds of pebbly conglomerate

Such unequally resistant beds, folded, raised and exposed to the elements, weather and erode at different rates Every crack along the folds is an incipient focus of destruction at which chemical and physical forces may attack The hard or resistant outlast the soft or soluble. Slowly, by processes of rotting away, wearing away and carrying away, the long, parallel folds of rock were etched out to yield long, parallel ridges and valleys Yet these are not today's

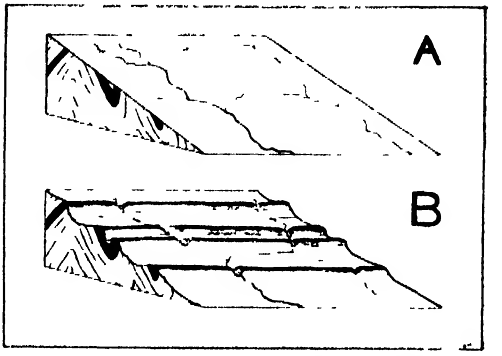

FIG 5 WATER AND WIND GAPS

DIAGRAMS SHOWING THE DEVELOPMENT OF THE GAPS. (A) NEWLY UPLIFTED (TILTED), PENEPLANED SURFACE UNDERLAIN BY FOLDED ROCKS OF VARYING HARDNESSES, CONSEQUENT STREAM PATTERN DEVELOPED (B) SUBSEQUENT STREAM PATTERN DEVELOPED THE MASTER STREAM, LEFT, HAS MAINTAINED ITS COURSE ACROSS DEVELOPING RIDGES, A SECONDARY STREAM, RIGHT, HAS BEEN CAPTURED, LEAVING A WIND GAP TRIBUTARIES ARE ADJUSTED TO NON RESISTANT, VALLEY FORMING BEDS THE HARD, RIDGE MAKING ELEMENT IS IN BLACK ON THE LEFT OF THE DIAGRAMS

relief features, another cycle of uplift and degradation came on Given sufficient time, a factor with which geologists are always generous, even the hardest beds would conceivably be reduced essentially to sea level The folded, raised, eroded region of geosyncline-formed sediments was brought low to a nearly featureless surface Over it, eastward wandering rivers wound complacently to the not-so-distant Atlantic Ocean. Note well that these streams ran eastward, not westward as in the ancient days of the geosyncline and Appalachia Already modernization was foreshadowed

Once again uplift affected the degraded or peneplaned folds Once more the region was pushed bodily up even as high as the loftiest crests of the present Appalachians But the rate of elevation was so gradual that the principal streams "kept the noiseless tenor of their way." Holding to their original, winding courses inherited from old peneplain days, rivers ancestral to the Delaware,

Lehigh, Susquehanna, Schuylkill and Potomac, some lesser, local streams, too, continued to flow along essentially the lines already established Beneath the raised but nearly flat surface of the peneplain, grovelled folded rock-roots of humbled mountains. The hidden rocks resembled wood grain, parallel or converging bands Like the well-worn, foot-wide floor boards of some colonial farm house, long erosion might bring into relief hidden inequalities Because some rivers were large, powerful, they cut cross-grain impartially through hard and soft rock bands alike (Fig 5) The lesser side-streams, the small tributaries, incapable of maintaining their courses, adopted paths of least resistance and presently adjusted themselves to flow along the bands of soft or soluble, non-resistant rock Where the master streams crossed such bands along their valleys, the tributaries made confluence with them Again, the whole, rising surface was etched out into a series of parallel ridges and valleys, carved from the established rocky grain of the country Through the ridges the mightier rivers cut deep gashes, the water gaps Down the side valleys the lesser water courses meandered to join the master streams

On some clear day stand atop one of our ridges How long and straight it looks! Sight away off across adjacent mountain tops. Note the gaps, but see also how ruler-straight is many-a ridge top Can it be that each ridge crest is a trace or remnant, a part of the ancient peneplain? Such is the explanation. Each ridge is composed of harder rock which remained upstanding as a remnant while soft beds were gouged out in valleys, deeply eroded below the peneplain surface

The story behind the gaps is not quite done We have still to tell how the wind gaps fit into the scheme of landscape etching During the process of gap cutting and valley erosion when the old peneplain was rising, there were certain streams, now extinct, whose courses lay across the grain For one reason or another they failed to maintain those courses, were eventually diverted to easier, grain-parallel routes But, during the time when they were engaged in

FIG. 6. IN THE RIDGE AND VALLEY SECTION OF FULTON COUNTY
NOTE THE LONG, EVEN-CRESTED RIDGES UNDERLAIN BY UP-TILTED, HARD BEDS. THE INTERVENING VALLEYS ARE CUT IN SOFTER ROCK. ONE OF THE RIDGES IN THE MIDDLE DISTANCE IN THE PICTURE IS BREACHED BY A GAP

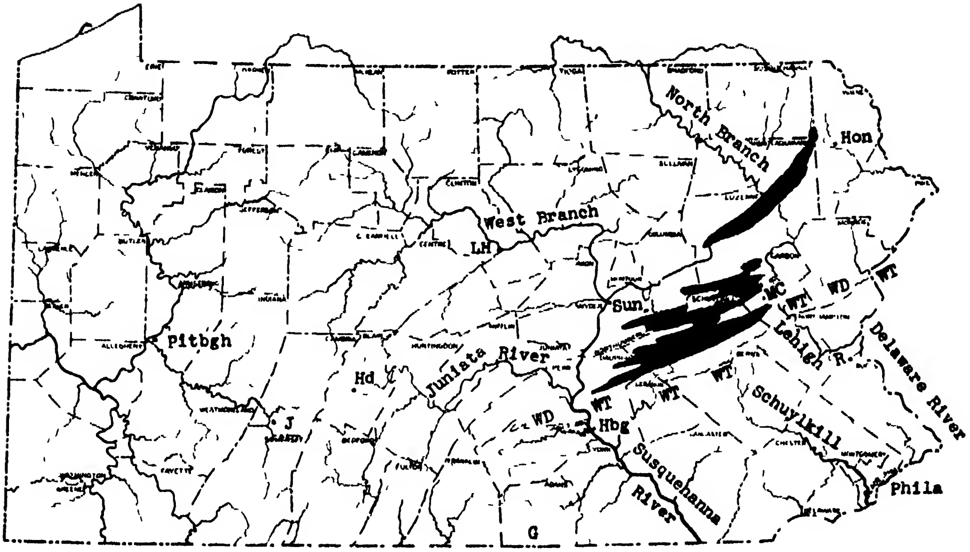

FIG. 7 SKETCH MAP OF PENNSYLVANIA

SHOWING PRINCIPAL RIVERS, WATER AND WIND GAPS AND IMPORTANT TOWNS MENTIONED IN THE TEXT ANTHRACITE FIELDS ARE IN BLACK KEY WD, WIND GAP, WT, WATER GAP; G, GETTYSBURG, HBG, HARRISBURG; HD, HOLLIDAYSBURG; HON, HONESDALE; J, JOHNSTOWN; LH, LOCK HAVEN, MC, MAUCH CHUNK, PITBGH, PITTSBURGH, PHILA, PHILADELPHIA; SUN, SUNBURY.

transecting the resistant bands, appreciable gaps were made. With stream diversion, such notches were left dry, literally thrown to the winds So, each wind gap today marks the deserted channel of a defunct river What has been the influence of these wind gaps and water gaps upon man and his works and movements?

Man Uses the Gaps

Early Strategic Importance

In Colonial days, few white men from the east penetrated the Appalachian Mountains in the region of Pennsylvania and southward. The broad path of the Hudson and Mohawk valleys to the north was early known and used About the year 1732 men moving out along the Potomac in Virginia entered the Shenandoah Valley. Twenty years later the first drops of the great stream of migrants began to pass from Pennsylvania and Maryland into the headwaters of the Ohio To the south Daniel Boone's journeys blazed sunset trails for the people of North Carolina and Virginia. While Boone's Wilderness Road led into Kentucky and Tennessee, others penetrated Pennsylvania from Philadelphia to the region of present-day Pittsburgh and from Baltimore out along the Potomac Valley. Of these, Boone's was probably most used in pre-Revolutionary days. It is said that several thousands of people passed over it yearly. All of these advances followed through or were influenced by natural topographic routes, that is, river valleys and mountain gaps. Such natural routes have ever since dominated travel from the Atlantic seaboard west through the Appalachian barrier

In contrast to the relation to transmontane journeys of Colonial times, the mountains served as a welcome rampart and protection against the revengeful savages bent on exterminating the white usurpers of their ancestral homes along the coast. The mountain gaps, con-

versely, were at times a genuine menace rather than an asset For ages the red men had traveled them. Through them threaded the war and hunting parties. They were routes of savage migration and primitive trade With the establishment of the whites on the lowlands to the east, the gaps became ideal Indian ports of sortie upon the unwelcome settlers.

This was particularly emphasized during the conflict with the French and Indians Facing each important gap, a blockhouse presented its sturdy walls against surprises Many of these strategically distributed forts from the Delaware to the Susquehanna were erected through the foresight of Benjamin Franklin Typical of defenses were those at the Lehigh Water Gap, which figured conspicuously in frontier forays and bloody Indian fights A blockhouse is reported to have existed as early as 1739 near the present town of Northampton in Northampton County Later forts guarded both sides of the river below the Gap. Such forts were usually small, octagonal structures with loop holes and a door but no windows through their two feet thick walls. Today there remain few of these forts. Sites of vanished others are appropriately commemorated by markers and monuments. Names, too, reminiscent of our early wars, cling as in Fort Hunter, Forty Fort and Fort Louden

White men made military use of the gaps during the last of our colonial wars When Braddock's ill-adapted troops trudged arduous miles westward across southwestern Pennsylvania against Fort Duquesne, every advantage was taken of such gaps as there are in our more southern mountains. Wagon trains meant wagon roads Braddock's Road became in time one of our principal routes of travel to the west, and parts are incorporated today into our modern highways Because Braddock's road was built partly under the direction of George Washington, we may truly number the First President among those responsible for the beginnings of our

FIG. 8. OLD INDIAN FORT

LOCATED IN BERKS COUNTY THE FORT IS THE SMALL STONE BUILDING WITH A CONICAL ROOF.

present highway system. Bedford County had its first permanent white settlement in 1750 at "Raystown." Five years later, 1755, a wagon road was opened from Fort Louden west to join Braddock's Road in Somerset County. Further development came when Forbes' army erected a fort at Bedford, 1758. Forbes followed a trail called Nemacolin's after the Indian guide. Begun at Cumberland, Forbes' Road pursued a somewhat north of west course to the Youghiogheny, utilizing a number of small gaps. The road intersected the River at the "Great Crossing" south of the present town of Somerfield.

Military uses of the gaps again figured in the Revolutionary War. As before, the mountains formed a barrier, but the gaps had to be defended. The Wyoming massacre effected by a British raid down the Susquehanna, was a realization of an attack such as was constantly feared. Before the close of the war, the Colonial troops of General Sullivan's punitive expedition into western New York were on the march. This is an instance of military use of the gaps. Setting out from Easton, Pennsylvania, in the early summer of 1779, Sullivan's army traversed the Wind Gap (Fig. 2), went past Tannersville, at that time an outpost of civilization, over the Pocono Plateau to Fort Wyoming (now Wilkes-Barre) and thence up the Susquehanna Valley into New York. In collaboration with Sullivan, Colonel Daniel Brodhead led another party up the West Branch of the Susquehanna into northwestern Pennsylvania. Fort Augusta (Sunbury today) at the forks of the Susquehanna was a base of supplies. So, in these troop movements during the War for Independence, the river routes and the gaps proved the best lines of march.

Roads and River Boats

The Revolution was followed by the steady increase in westward movement of a people which until then had remained essentially confined to the seaboard. The nation was determined to expand across the mountains into the fabulous Ohio Valley lands. With the removal of Indian menaces, river-following trails became roads which through improvement gradually grew into the main communication arteries of the early Republic. Typical of these was the National Road or Cumberland Turnpike which was built during the years 1808 to 1817. It connected the Potomac with the Ohio. Slowly, but with acceleration, crooked Indian trails evolved into tote-roads, pack-roads and wagon-roads in turn. "Practically the whole present-day system of travel and transportation in America east of the Mississippi River, including many turnpikes, is based upon, or follows, the system of forest paths established by Indians hundreds of years ago."[1] Gradually, horses and "shanks mares" were displaced by carriages and coaches. First introduced as public vehicles in the Colonies about 1730, it was not until long afterward that the coach was used in trans-montane journeys. The need of better roads developed soon with the increase of travel across the Alleghenies. The first fundamental improvement appears to have been in response to the use of wheeled vehicles, when a reasonably firm surface became imperative. Even after coach roads were well established in the east, it was impossible to go west by this means. A journey from Philadelphia to Pittsburgh soon after the Revolution permitted the use of the coach only to Shippensburg, 140 miles, the remaining 170 had to be made a-foot or a-horseback. For freight transport, the pack train presently was superceded by the Conestoga wagon, ancestor of the prairie schooner. These famous vehicles are gone save as museum pieces; but the name is immortalized, if not too honorably, in those all-powerful cigars,

[1] Dunbar, Seymour, "A History of Travel in America," 1937, p. 19.

FIG 9 CRUMBLING MASONRY—REMAINS OF ONCE BUSY CANAL LOCKS
THE LOCKS PICTURED ABOVE ARE ON THE SCHUYLKILL CANAL ABOVE HAMBURG, BERKS COUNTY.

the "stogies" or "conestogies". Reputedly, none but the cast iron constitution of the driver of a Conestoga ("Stogie") wagon could survive this species of fumigation Roads continued to press westward, even beyond the mountains. The Cumberland Road was eventually extended into the Mississippi Valley as the main east-west route from the Original Thirteen to the newly admitted Middle Western States. Over it streamed coaches, freight wagons, pack trains in interminable parade. Its construction was partly dependent upon the use of water gaps in overcoming the mountains that lay across its path.

But even as the Pennsylvania-made "Kentucky" rifle cleared the forests of Indians and the Pennsylvania-invented Conestoga wagon hauled the settlers' goods along the new roads, accounts of another means of transportation were on men's tongues This means was water travel. The canal did not come into immediate use. Its development as a low-grade route was antedated by earlier and cruder trials of methods of water transportation In the beginning use was made directly of unimproved, natural waterways

The Indians had devised two types of boats, the bark canoe and the dugout or pirogue Civilization brought larger and more serviceable craft Several types were developed for river navigation, among them the ark, barge and keel boat. The name pole boat was in common use designating almost any type which was worked laborously upstream by means of poles pushed against the bottom by the crew The ark, on the other hand, was a massive, heavy-timbered affair intended merely for floating down stream largely as the current willed. Arrived at its destination, it was commonly broken up and sold for timbers. The

barge was built lighter, more along the lines of a canoe. It could be pushed up stream. Some barges were fitted with a mast and sail and provided with a shelter for crew or passengers. Of peculiarly Pennsylvanian origin was the Durham boat capable of carrying some 15 to 20 tons of freight. It differed from the keel boat in that it lacked the distinctive keel of the latter, though provided with mast and sail. Timber rafts were also plentiful Hundreds of them annually came down the Susquehanna to Harrisburg with high water

Originally most of the boats carried lumber, farm produce, furs and passengers With the growing exploitation of anthracite, various types of craft were used as coal-bearers By them, anthracite could be shipped to Philadelphia and other seaboard destinations Steam navigation of the shallow rivers of Pennsylvania proved a failure A line of small, shallow draft steamers is said to have operated on the Susquehanna and Juniata as far as Millerstown, but it was soon abandoned Ice in winter and low water in summer proved two costly interruptions or hindrances to navigation

So, through adoption and adaption of several boat types, the rivers were put to use Once more the gaps saw a new type of transportation taking advantage of such convenient passages of the mountains. In the river craft, the coming of the canal was hinted River boats at best were a makeshift Indeed, it was in the very fact that they were makeshifts that the idea of canal building found its support if not its inception For years, the people had believed that the rivers afforded sufficient channels for all commercial navigation However, it was realized that certain obstacles, principally rapids or falls, along the streams, were serious problems to the river boats, especially in times of low water. Therefore, it was presently proposed that means of bypassing these barriers be devised and installed. Even before the Revolution, in the early 1760's, public agitation called for and suggestions were made to improve water transportation along the Susquehanna River and the Schuylkill Benjamin Franklin early recommended betterment of the waterways, if not the actual construction of canals. In 1772 he is reported to have advocated improved navigation conditions along the Schuylkill with a view to opening the back country At that time, be it reiterated, coal was not an article of river traffic. George Washington, too, seems to have been impressed, doubtless in part because of his experience in surveying He was influential in promulgating as far back as 1784, the plan for the Chesapeake and Ohio canal With a view to opening navigable water communication through to the West, surveys were made and reports submitted

(To be concluded)

HOPI SNAKE HANDLING

By Dr. MISCHA TITIEV
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EVER since 1884, when the Snake Dance of the Hopi Indians was first described in detail, attention has centered on that portion of the ritual during which some of the performers carry live snakes, including dangerous rattlers, dangling from their lips[1] Again and again observers have wondered why it is that venomous reptiles are so freely handled, yet rarely is a Snake dancer bitten, and never has a fatality been reported among participants in the ceremony Many theories have been proposed to account for this phenomenon, some writers attributing the scarcity of accidents to the remarkable skill of the snake handlers; others quoting members of the Snake Society who have claimed that they are immune to harm if their characters are good; and one author referring vaguely to a medicine which may stupefy the reptiles while they are being carried in the mouths of the performers

On the whole there seems to be little need for postulating the use of drugs or the possession of any extraordinary or mysterious quality to account for the relative infrequency of injuries to the Snake dancers Such unwarranted "explanations" have been completely dismissed by L. M Klauber, curator of reptiles at the Zoological Society of San Diego, who has expressed the belief that accidents are rare partly because most rattlesnakes bite far less frequently than is commonly thought, and partly because all reptiles tend to become lethargic and docile after they have been handled in captivity for a number of days[2] It may well be that Hopi dancers are fairly clever snake handlers, but in Klauber's opinion they are bitten just about as often as would be the case among a comparable number of white men who had been trained to deal with snakes

If it be granted that native performers are actually stricken by venomous reptiles from time to time, as our records reveal, how does it happen that they seldom show ill effects and apparently never suffer death?[3] To this question the conventional answer has been that the Indians possess a secret medicine which serves as a potent immunizer or antidote. However, when tested in the laboratory the Hopi remedy has failed to show any efficacy This was established by Dr. George E Coleman, who once managed to secure about a pint of the reputed Hopi antidote with which he conducted experiments on a number of guinea pigs Unfortunately, the liquid was no longer fresh at the time that the tests were made, but under the prevailing conditions, Dr Coleman concluded that "the antidote certainly does not neutralize the venom in vitro"[4]

Since there is no indication that the Hopi medicine possesses any therapeutic

[1] In reality, the so called Snake Dance is only a brief public spectacle which comes as the culmination of a nine day esoteric ceremony. One of the fullest and most accurate descriptions of the entire ritual may be found in G A. Dorsey and H. R. Voth, "The Mishongnovi Ceremonies of the Snake and Antelope Fraternities," Chicago: Field Columbian Museum, 1903.

[2] L M Klauber, "A Herpetological Review of the Hopi Snake Dance," *Bulletin* No. 9, Zoological Society of San Diego, 1932, p. 32.

[3] For example, J W. Fewkes, *Journal of American Folk Lore*, 8: 280, 1908, tells of a dancer who was bitten, presumably by a rattler. Yet, his "wound was not fatal, nor did his hand swell up, as ordinarily happens a few hours after such a mishap"

[4] G. E. Coleman, *Bulletin of the Antivenin Institute of America*, 1: 99, 1928.

value, we must seek some other explanation for the lack of serious consequences when snake men are bitten by venomous reptiles. This brings us to the crux of our problem—are the poisonous snakes defanged, or "milked" of their venom, at some time prior to the public portions of the ceremony? These points have been widely debated, and a review of the literature pertaining to the Snake Dance clearly reveals that the great majority of authors favor the proposition that the reptiles are not rendered innocuous by either of these methods. This attitude was first expressed in 1884 when Bourke wrote, "Let it not be imagined that these snakes were harmless, that their fangs had been extracted, . . . we were all convinced that they had been subject to no treatment whatever."[5] Nearly twenty years later, Dr Dorsey took a similar stand. "This much may be said with confidence," he wrote, "there is absolutely no attempt on the part of the Hopi to extricate the fangs or in any other way whatsoever to render the snakes harmless."[6] Still another writer, one never given to understatement where the American Indians are concerned, waxes almost hysterical at the accusation that the Snake Dance is a fake because the reptiles have been made safe. "Any one who knows anything about rattlesnakes," he maintains, "knows that they can not be rendered harmless except by killing them. For the snake dance, their fangs are not extracted . . . the snakes are certainly not rendered innocuous."[7]

Such has been the prevailing opinion until recent times. While it is true that none of the authors quoted above had actually examined any of the reptiles carried in the dance, their conclusions have occasionally been given weight by the observations of trained herpetolo-

[5] J. G. Bourke, "The Snake Dance of the Moquis of Arizona," p. 140. New York: Charles Scribner's Sons, 1884.

[6] G. A. Dorsey, "Indians of the Southwest," p. 154. Santa Fe, 1903.

[7] C. F. Lummis, *Sunset Magazine*, 52: 32, 1924.

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FIG. 1. THE START OF A SNAKE HUNT

MEMBERS OF THE SNAKE SOCIETY AT ORAIBI LEAVING THEIR KIVA TO HUNT FOR SNAKES ON ONE OF THE DAYS PRECEDING THE PUBLIC DANCE. NOTE THE LONG DIGGING STICKS WHICH THEY CARRY.

gists. At the Walpi performance of 1883, for example, an army doctor named H C. Yarrow entered the snake kiva just before the public dance, selected a large rattler at random, and "upon prying its mouth open, he found the fangs intact and of large size."[8] Furthermore, at the conclusion of this same ceremony, two rattlesnakes were captured and sent to the National Museum where Dr. S. W. Mitchell reported that "Their fangs had not been disturbed . . ."[9]

The view that the reptiles are not defanged received additional support from Klauber after he had witnessed the Snake Dance at Mishongnovi in 1931 During this performance, Klauber and his son independently noted two rattlesnakes (*Crotalus confluentus confluentus*) which revealed their fang sheaths when their mouths were open, an indication that the fangs had neither been

[8] C. Mindeleff, *Science*, 8· 12, 1886.

[9] *Idem.* It should be noted that no proof was ever offered to show that the rattlers examined by Yarrow and Mitchell had actually been used in the dance.

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FIG. 2. INSIDE A SNAKE KIVA

YOUTHFUL MEMBERS OF THE SNAKE SOCIETY GUARDING THE REPTILES WHICH ARE SOON TO BE USED IN THE SNAKE DANCE.

removed nor cut short. On the basis of these personal observations, coupled with a thorough examination of the publications pertaining to the subject, Klauber concluded that "the case for the non-disturbance of the fangs is proven. . . "[10]

Nevertheless, in the light of a mass of recent data, it is no longer possible to regard the issue as closed; for it can now be demonstrated that the Hopi do, at least on some occasions, defang their snakes The first writer to uphold this viewpoint was E S Curtis, who expressed considerable surprise at the lack of skepticism shown by many students of the Hopi, and who quoted an experienced snake performer to the effect that the rattlesnakes are "rendered absolutely harmless by the removal of their fangs "[11] During the course of a field trip to the Hopi in the summer of 1932, I encountered my first bit of evidence in support of Curtis' position Together with other members of the party of which I was a member, I was present at Oraibi when an elderly native, formerly enrolled in the Snake Society, voluntarily began to deprecate the ceremony because it failed to bring rain and because the snakes were defanged. In pantomime the speaker showed us how a snake's open mouth was rubbed up and down against something that protruded upward from the ground At the time very little attention was paid to the old man's remarks because he spoke so little English that we could not be absolutely certain of his meaning, and because he had long been a convert to Christianity and there was a possibility that he was seeking to discredit his former religion.

Several years later this little episode took on an added significance when two similar reports of defanging were brought to the writer's attention from

[10] L. M. Klauber, *op. cit.*, p 39.

[11] E. S. Curtis, "The North American Indian," 12: 136, 1922.

other sources. Once again the information came from Christian Hopi, who, having abandoned their native faith, were now seeking to malign it. However, both men were giving their testimony to an official of the Office of Indian Affairs, and inasmuch as some of their evidence has since been corroborated by an unimpeachable investigator, it may well be that there are elements of truth in their depositions One witness explained that he had been greatly frightened when he was ordered to catch the first snake during his novitiate, but that the snake chief had later revealed "that they had extracted the snake's fangs, teeth and poison sacs before calling him up to bag it "[12] The speaker then went on to say that the operation was secretly performed with a hoe-like instrument, and that the poisonous snakes were examined prior to the dance to make sure that their fangs had not grown back

A second witness, testifying in the same vein, gave additional details According to his story, when he was a novice an experienced snake man named Satsiki had instructed him "to place his snake stick with the butt end in the ground, and the flat end in the air Satsiki then seized the snake just back of the head, squeezed its jaws, to force them open, and rubbed the jaws along the flat side of Deponent's snake stick, thus breaking out the snake's fangs and teeth, and squeezing out the poison sacs He then told Deponent: 'This is the way we treat the snakes, so as not to be bitten ' "[13] Later on in his testimony, this witness also claimed that the snakes are examined before the dance and are again defanged if necessary.

Such statements by renegades from their native religion might well be dismissed as biased and untrustworthy were it not for the fact that they have recently received striking confirmation in at least

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FIG 3 THE ORAIBI SNAKE DANCE

IN THIS VIEW THE CARRIER IN THE FOREGROUND IS STILL DANCING WITH A SNAKE AT HIS LIPS, WHILE THE YOUNG GATHERER AT THE LEFT IS ABOUT TO PICK UP A REPTILE WHICH ANOTHER DANCER HAS RELEASED.

one instance At the close of the Chimopovy Snake Dance on August 24, 1932, C. M Bogert, now assistant curator of herpetology at the American Museum of Natural History, followed one of the performers and watched him liberate his quota of reptiles at a shrine. As soon as possible after the dancer had withdrawn, Bogert hurried to the spot and succeeded in capturing a single rattler which had not yet escaped into the open. His published account of this adventure is directly pertinent to our discussion:

> In the sanctum of a gully not far from the shrine, a stop was made to examine the rattlesnake in case anything were to happen which might not later allow us the opportunity to do so From Klauber's observations, and from the accounts of most ethnologists (except Curtis . .) I fully expected to find the venom apparatus intact. Therefore, it was something of a surprise, upon prying the snake's mouth open with a pencil, to find the fangs entirely lacking and obviously removed. With the object of learning something regarding the condition of the venom glands, pressure was applied with the thumb and finger to the proper region, but no venom, at least none recognizable as such, was forced into the mouth. Of course, with the fangs removed, it would be difficult to observe and identify a discharge of venom.[14]

[12] Taken from a transcription of a report in the files of the Office of Indian Affairs, 1920.

[13] *Idem.*

[14] C. M. Bogert, *Copeia*, No. 4, 1933, p. 220. A fuller account of this entire affair has recently been published by Bogert in *Natural History*, 47: 276–283, 1941.

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FIG 4. AN EARLY STAGE IN THE HOPI SNAKE DANCE AT ORAIBI

MEMBERS OF THE SNAKE SOCIETY (ON THE LEFT) AND OF THE ANTELOPE SOCIETY (ON THE RIGHT) ARE SINGING IN UNISON. AT THIS STAGE THE REPTILES ARE HIDDEN WITHIN THE COTTON-WOOD SHELTER AT THE EXTREME RIGHT

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FIG. 5 THE ORAIBI SNAKE DANCE IN PROGRESS

THE CARRIER IN THE CENTER STILL HOLDS A SNAKE TO HIS LIPS, WHILE THE CARRIER AT THE LEFT IS ABOUT TO RELEASE A SNAKE WITH WHICH HE HAS FINISHED DANCING. SPECTATORS WATCH FROM THE ROOF TOPS OF THE NEAR-BY BUILDINGS.

In order to have his own examination made in the field confirmed, Dr. Bogert later sent the snake to Klauber. Under date of September 16, 1932, Klauber sent a letter to Bogert which reads in part:

I pickled the snake last night and found as you had supposed that apparently not only the functional fangs had been removed, but all of the rudimentary fangs as well. In fact, it would appear that the sockets in the maxillary which normally hold the functional fangs, were completely extirpated. This has been done with a knife as indicated by cuts rather than tears, and on the whole it was rather well done, if you forget the snake's feelings in the matter. . . ."[15]

Thus, within a period of nine months after he had concluded that "the case for the non-disturbance of the fangs is proven," did Klauber cheerfully admit that the opposite was undoubtedly true in at least one instance.

Of course, as Bogert is careful to point out, the discovery of a single defanged rattler does not imply that all the dangerous reptiles are defanged; nor must we forget that Yarrow and Mitchell had found rattlesnakes which had not been operated upon. In the latter instance, however, there is still the possibility that the Indians had resorted to the simpler method of rendering the snakes harmless by "milking" them of their poison. It is significant that even at the time when Klauber was convinced that the Hopi did not defang their snakes, he had indulged in an interesting bit of conjecture on this score. "To my mind," he wrote, "the removal of the venom . . . would be so easy and safe, and so much more difficult to detect, that this is a more plausible explanation of how the Indians handle the snakes so fearlessly and with so few adverse effects, . . ."[16] He then goes on to state that the removal could readily be accomplished by letting the reptiles strike at some soft object, or by manipulating their venom glands.

This hypothesis finds support not only in the testimony of the Christianized natives cited above, but also in the words of a faithful Hopi. In an interview with Stephen in 1885, Wiki, an orthodox Hopi official, who had long served as Antelope chief of Walpi, remarked, "The snake whip is used to cause the snake to strike at it repeatedly and exhaust the venom. As soon as the venom sac is empty the snake straightens out, and he is then seized."[17] Thanks to Wiki's authoritative testimony, it is plainly evident that even if the Hopi do not invariably defang dangerous reptiles, they may still render them harmless by a "milking" process.

Armed with the knowledge that the Hopi do, at least occasionally, take pains to make their snakes safe, we may now venture to read somewhat between the lines in a few of the earlier publications, in order to point out the strong probability that the members of the Snake Society have long conspired to hide their treatment of snakes from white observers as well as from their fellow tribesmen. To begin with, it should be explained that whereas the Hopi have sometimes permitted spectators to watch nearly the entire schedule of rites, they have usually managed to secure privacy just before the public dance begins, and on the occasion of snake hunts. For example, Bourke reports that he and his companions were allowed ready access to the snake kiva at Walpi in 1881, but just as the public exhibition was about to begin one of the old men persuaded them to leave lest their clothing be stained by the paint which the dancers were apply-

[15] C. M. Bogert, *Copeia*, No. 4, 1933, p. 220. It should be noted that the cuts which Klauber mentions might possibly have been inflicted by the metal-bladed digging sticks which the Snake men carry when they go to hunt for snakes on four successive days prior to the public dance (see Fig. 1). In recent years the men often carry knives on these occasions.

[16] L. M. Klauber, *op. cit.*, p. 41.

[17] A. M. Stephen, *Hopi Journal* (E. C. Parsons, ed.), New York: Columbia University Press, 1936, p. 585. The Antelope Society, of which Wiki was the chief, is a partner of the Snake Society, and combines with it in the performance of the rites. See Fig. 4.

ing to their bodies [18] To any one who has ever lived in a Hopi pueblo the old man's ruse is perfectly clear, for the one thing to which elderly Hopi are most completely indifferent is dirt of any description!

Even more revealing are the subterfuges employed to keep spectators from witnessing the snake hunts. Uninitiated tribesmen are kept away by a stock device of Hopi ceremonialism. They are warned that those who trespass on the hunting grounds will either be stricken with fatal swellings (a disease supposedly controlled by the snake cult), or else they will be forced to join the Snake Society, a contingency which is dreaded by the average Hopi As for white men, either they are simply requested not to come into the neighborhood of a snake hunt, or else they are told that the presence of strangers will interfere with the success of the searchers The language in which Stephen was forbidden to join a party of hunters is particularly significant "They say it will be bad for the young snake members who are to catch their first snakes to-day," he comments [19] It is only when we recall the vivid testimony of the Christian deponents (*vide supra*) that we can fully appreciate why the presence of a white man would have been "bad" for the novices

Perhaps the strongest "between-the-lines" testimony of all is to be found in the Reverend H R Voth's account of an incident that occurred at Oraibi in 1896 When it was learned that Voth was bent on joining a hunting party, the older snake men became greatly upset. At first they merely insisted that his presence would make the search unsuccessful; then they literally begged him not to go along; and finally they offered to strike a bargain with him As Voth relates their terms, "I could see and hear everything else, only I should do them the favor and not go with them on the snake hunt"; and when Voth agreed to these conditions, "a big burden seemed to have rolled from their hearts "[20]

On a different occasion, however, Mr. Voth did actually accompany a group of hunters from Oraibi. Unfortunately, he was afraid that he would not be able to keep up with the more vigorous searchers, so he elected to follow the old snake chief who was "entirely blind in one eye, the other one being very poor," and another man who was also "old and feeble, and also nearly blind "[21] Needless to say, Voth saw no snakes captured, and we may imagine the laughter of the younger snake men at the prospect of Voth's endeavor to discover their secrets by following a pair of feeble, dim-sighted old men

By one means or another the Hopi Indians have generally succeeded in preventing outsiders from watching their snake hunts at close range Only Stephen has published an eye-witness account, but it is evident from his report that the snake which he saw taken had first been found by a distant hunter who had then called the rest of the party to him [22] Had this man so desired, he could have operated on the creature before summoning the others to watch its capture—a trick which experienced Snake men apparently play on novices.

In one instance Dr Fewkes showed Kopeli, head chief of the Walpi Snake Society, a hole in which he had noticed a rattlesnake, but Kopeli flatly refused to dig it out in his presence. Fewkes attributed Kopeli's refusal to the great care with which he was trying to "preserve this one feature of the ceremony, the capture of the reptile in the open";[23]

18 J. G. Bourke, *op. cit*, p 151

19 A. M. Stephen, *op. cit*, p 608.

20 H. R. Voth, "The Oraibi Summer Snake Ceremony," p 292. Chicago: Field Columbian Museum, 1903.

21 *Ibid*, p. 290.

22 Quoted in Klauber, *op. cit.*, pp. 68–69. I have not had an opportunity to check the original source.

23 J. W. Fewkes, *op. cit.*, p. 277.

but somewhat naively, Fewkes overlooked the possibility that Kopeli might actually have been afraid of a genuinely dangerous rattler. In support of the more realistic interpretation of this episode, we have Voth's explicit statement that "At any other time except during the ceremonial days, the members of the Antelope and Snake Fraternity seem to be just as much afraid of a rattlesnake as other people"[24] On a number of occasions Voth challenged snake men to pick up rattlers which he had discovered, but this "they very emphatically refused to do, saying that if they . . touched a snake while they were not 'assembled' they were just as liable to be bitten as any other person"[25]

As for the Antelope men, their fear of untreated rattlers may be so great as to border on the ludicrous In one case Voth dared a friend of his, an Antelope Society member, to pick up a rattlesnake When he refused, Voth struck the snake a blow, picked it up and began to pursue his friend who "dashed away and screamed, evidently in genuine fear, crawled . under a wire fence, and ran away as fast as his legs would carry him . . "[26] It might be argued, of course, that the person whom Voth had so badly frightened was an Antelope man, and as such he may not have had the skill in handling reptiles that the snake men learn to acquire; yet, had this same individual been handed a rattlesnake by one of the gatherers at the public spectacle, he would have held it with apparent nonchalance as he sang and rattled in the fashion prescribed for his group.

Summary and Conclusion

In the course of the Hopi Snake Dance the participants handle with impunity several varieties of reptiles including the prairie rattlesnake, whose bite may have very serious consequences. Nevertheless, dancers are rarely stricken and never fatally injured. This immunity results neither from the use of stupefying drugs nor from the employment of therapeutic immunizers or antidotes Instead, the safety of the performers is achieved partly by making the snakes docile through careful handling in captivity, and partly by resorting to such devices as defanging and emptying the venom glands Although the latter practices have been frequently denied by former writers, a review of all the evidence available clearly points to the conclusion that the Hopi can, and occasionally do perform such operations; perhaps with the metal-tipped digging sticks and feather "whips" which are part of the Snake Society's equipment

It would be unwarranted, in the present state of our knowledge, to claim that all the rattlesnakes used in the ceremony are made harmless; but on the other hand, it can no longer be maintained that the snakes are never treated or that the Hopi dancers are recklessly indifferent to the dangers of venomous snake bites In all likelihood, future researches will reveal that the major operations are performed systematically, according to some pattern of ritual procedure that has not yet been discovered Indeed, it is already reasonably certain that the greatest care is exercised to render rattlers innocuous on those occasions, like snake hunts, when novices are about to handle them for the first time In my opinion this is done both to protect the tyros from harm, and to inspire them with the necessary confidence so that they may perform in public with that air of calm indifference to great danger which makes the snake dancer a hero to his own people, and an object of awe and admiration in the eyes of white spectators.

24 H. R. Voth, *op. cit.*, p 357.
25 *Ibid.*, p. 358.
26 *Idem.*

OCCUPATIONS OF EMINENT MEN

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OCCUPATION is an important consideration in studies of eminent men for two reasons. In the first place, the achievement for which a man gains recognition is usually directly associated with some vocation or occupation, whether or not the person is gainfully employed. All men, including those socially recognized, can be classified according to the field of endeavor in which they have been active. In the second place, and of far more importance, is the fact that occupations differ in prestige and in opportunities for eminence possessed by persons engaged in them. It is the purpose of the present discussion to summarize the most important available information on the vocational affiliations of both historical and contemporary notable men and women; and to present some new data on chances for eminence possessed by persons in certain occupations.

OCCUPATION AND HISTORICAL EMINENCE

The most serviceable data for studying the relationship between occupation and historical eminence are those from the studies of amount of space occupied by the biographies of men famous in different occupations Cattell's list showed that the outstanding occupations for the one hundred most eminent persons of history, as analyzed forty years ago, were sovereign, poet and philosopher.[1] Table I presents a detailed classification.

Because several of these one hundred persons were extremely versatile, matters will be clarified somewhat if a tabulation is made of the actual number of times each vocational class appears in the group. This is done in Table II The most frequent occupation is that of philosopher, with statesmen close behind,

[1] J. M. Cattell, *Popular Science Monthly*, 1903, 62, 369–377.

TABLE I

MAJOR OCCUPATIONS OF THE 100 MOST EMINENT PERSONS OF HISTORY

Occupation	N
Ruler	15
Poet	15
Philosopher	11
Statesman	7
Religious founder or reformer	5
Writer (essayist, historian, scholar)	5
Scientist	4
Philosopher and scientist	4
Statesman and writer (essayist, historian, scholar)	4
Soldier and statesman	3
Theologian	2
Soldier and ruler	2
Painter	2
Philosopher and statesman	2
Playwright	1
Playwright and poet	1
Philosopher and writer (essayist, historian, scholar)	1
Explorer	1
Poet and novelist	1
Admiral	1
Poet and miscellaneous writer	1
Painter, sculptor, architect and engineer	1
Statesman and scientist	1
Philosopher and ruler	1
Scientist, painter, sculptor, architect and engineer	1
Composer	1
Poet, dramatist and philosopher	1
Philosopher, religious leader and statesman	1
Theologian and statesman	1
Scientist, theologian and philosopher	1
Statesman, soldier and writer (essayist, historian, scholar)	1
Statesman, scientist and philosopher	1
Statesman, poet and writer (essayist, historian, scholar)	1

TABLE II

FREQUENCY OF AFFILIATION OF THE 100 MOST EMINENT PERSONS OF HISTORY WITH MAJOR OCCUPATIONS

Occupation	N
Philosopher	23
Statesman	22
Writer (poet, novelist, dramatist)	21
Ruler	18
Writer (essayist, historian, scholar)	13
Scientist	12
Religious founder and reformer	6
Soldier	6
Theologian	4
Painter	4
Architect	2
Engineer	2
Sculptor	2
Admiral	1
Composer	1
Explorer	1

"creative" writers (poets, novelists, dramatists) third, and rulers fourth. Among the three general groups, executive, intellectual and artistic leaders, the executive and intellectual leaders are almost equally represented, while artistic notables are considerably less numerous. Intellectual leaders (philosophers, writers—essayists, historians, scholars, scientists, theologians) represent 52 affiliations. Executive leaders (rulers, statesmen, soldiers, engineers, explorers, admirals) represent 50 affiliations. Art represents 29 affiliations (poets, novelists, dramatists, painters, sculptors, composers). There are some additional vocations more difficult to classify, which would alter the rank order of the main groups. Architects combine the qualities of engineers and artists And religious founders and reformers also offer some difficulties of classification. They exhibit extreme leadership, and some of them have proved to have exceptional executive talent But they also have been ideological leaders. Consequently, we may conclude that executive and intellectual pursuits are about equal in being the outstanding vocations for world eminence in the historical sense, and are considerably superior in this respect to artistic pursuits

Castle's study of the occupations of the eminent women of history discloses the fact that the literary occupation was far in the lead, while sovereigns ranked fourth, other politically influential women ranked tenth, persons eminent in religion ranked third, and scholars ranked ninth,[2] facts which indicate only a small amount of agreement between this study and the study based on Cattell's list. Castle's complete occupational data are presented in Table III.

TABLE III

OCCUPATIONS OF THE EMINENT WOMEN OF HISTORY*

Occupation	N
Literature	337
Marriage	87
Religion	64
Sovereign	59
Actress	56
Music	49
Birth	39
Mistress	29
Scholar	20
Political influence	19
Artist	17
Philanthropy	12
Tragic fate	11
Heroine	10
Motherhood	10
Reformer	9
Dancer	6
Literary character	6
Patron of learning	6
Beauty	6
Education	3
Revolutionist	2
Misfortune	2
Traveler	2
Adventuress	2
Physician	2
Fortune teller	1
Criminal	1
Conjugal devotion	1
	863

* Castle, *op cit*, p 40

Another study of interest is that of Huntington, based on 8,576 European persons of eminence who lived between 1600 and 1900 A D. The classification of occupations and the results are somewhat different from those already mentioned Persons famous in politics and revolution, war and adventure, "inheritance without merit" and business composed about 29 per cent. Writers of all sorts were grouped together so that the exact division of the artistic and intellectual pursuits remains rather indefinite, but about the same per cent of the cases were in the fields of "creative" literature and art. The intellectual group thus dominated, with about 9 per cent. famous in religion and philanthropy, about 3 per cent in philosophy and education, about 13 per cent in science, nearly 10 per cent in history and economics and at least 5 per cent.—perhaps more—in the writing of essays and criticism. About one half of one per cent. were classed as freaks, that is, were notorious but without merit or achievement.[3]

From Maas's study of 4,421 German leaders who lived between 1700 and 1910

[2] C. S. Castle, *Archives of Psychology*, No. 27, 1913.

[3] Ellsworth Huntington, "The Character of Races," p. 235. New York, 1924.

AD we have data that discloses the occupational distribution of eminent men of one country. The degree of eminence is not as great as that of Cattell's and Castle's limited groups, but the studies are roughly comparable. Maas distinguished seventeen vocational classes, five being in the artistic sphere, four in the practical sphere and eight in the intellectual sphere. Of the total cases the largest average for the professions was in the intellectual sphere, especially among theologians and philologists. Persons in practical fields were definitely fewer than artistic persons, which was contrary to the facts for the lists of most eminent men mentioned above Among the artists Maas included some of the more serious writers that Cox classified as intellectuals, and he did not include rulers The complete percentages are given in Table IV.

TABLE IV

EMINENT GERMANS CLASSIFIED ACCORDING TO VOCATIONAL GROUPS* (AFTER MAAS)

Vocation	Number	Percentage	Rank Order
Artistic Sphere			
1 Poets	290	6 66	8
2 Writers	202	4 57	10
3. Musicians	193	4 36	12
4 Creative artists	338	7 61	4
5 Stage artists	90	2 04	15
Total	1,113	25 17	(2)
Intellectual Sphere			
6 Theologians	504	11 40	2
7 Philologists	507	11 47	1
8 Historians	301	6 81	6
9 Pedagogues	118	2 57	14
10 Legal profession	323	7 31	5
11 Medical men	198	4 46	11
12 Exact scientists	179	4 05	13
13. Natural scientists	229	5 18	9
Total	2,359	53 37	(1)
Practical Sphere			
14 Statesmen	498	11 26	3
15 Agriculturists	69	1 56	17
16 Military men	295	6 67	7
17. Merchants	87	1 97	16
Total	949	21 46	(3)
Grand Total	4,421	100 00	–

* Adapted from P A Sorokin, C C Zimmerman and C. J Galpin, "A Systematic Source Book in Rural Sociology," Volume III, pp. 312-313 Minneapolis, 1932

OCCUPATIONS OF CONTEMPORARY EMINENT PERSONS

The most recent analysis of the occupations of contemporary notable Americans is for the 1938-1939 "Who's Who in America" Following the general classifications of the United States census the leaders have been classified according to five main occupational fields and some forty specific occupational classes, as shown in Table V.[4] Professional workers are in the lead, followed by proprietorial workers, protective service workers, farmers and farm managers and clerical workers, while all other kinds of workers, including craftsmen, machine operatives, domestic service workers and laborers are entirely unrepresented The most important specific occupations, in order, were college and university administration and teaching, writing and editing, law, religion, medicine and government service Other educators; financiers, insurance agents and real estate agents; and engineers also rank well up in the list. These results agree in general with several other studies [5]

TABLE V

OCCUPATIONAL DISTRIBUTION OF PERSONS LISTED IN "WHO'S WHO IN AMERICA," 1938–39

Occupation*	Number	Percentage	Rank Order
Professional and Semi-professional Workers	24,626	78 3	(1)
Professional	24,284	77 2	((1))
Actors	155	5	21 5
Architects	253	8	18
Artists and art teachers	900	2 9	12
Authors, editors and reporters	4,388	14 0	2

[4] Also see Fritz Giese, "Die offentliche Personlichkeit," *Zeitschrift fur angewandte Psychologie*, Supplement, 44, 1928, for an earlier detailed tabulation.

[5] For example, G. R Davies, *Quarterly Journal of the University of North Dakota*, 4: 225, 1914; Scott Nearing, *Popular Science Monthly*, 85: 189–199, 1914, and *Scientific Monthly*, 2: 57, 1916.

Chemists, assayers, metallurgists	124	4	23 5
Clergymen	3,006	9 5	4
College presidents, professors and instructors	4,996	15 9	1
Dentists . .	30	1	28 5
Engineers	1,165	3 7	10
Lawyers and judges . .	3,552	11 3	3
Musicians and music teachers .	679	2 2	14
Osteopaths .	13	04	32
Pharmacists . .	2	006	36
Physicians and surgeons . .	2,090	6 6	5
Social and welfare workers	145	5	21 5
Teachers (not elsewhere classified)	1,333	4 2	8
Trained nurses .	2	006	36
Veterinarians	27	1	28 5
Other professional workers .	1,424	4 5	7
Semi professional workers .	312	1 1	((2))
Dancers, showmen and athletes	20	1	28 5
Designers and draftsmen	40	1	28 5
Other semi professional workers . .	282	9	16 5
Farmers and Farm Managers	132	4	(4)
Proprietors, Managers and Officials, Except Farm	6,124	19 5	(2)
Government officials	2,060	6 5	6
Other specified managers and officials . .	230	7	19 5
Proprietors, managers and officials, not otherwise classified, by industry			
Mining	119	4	23 5
Construction	50	2	25
Manufacturing	838	2 7	13
Transportation, communication and utilities	290	9	16 5
Trade	211	7	19 5
Finance, insurance and real estate	1,273	4 0	9
Personal service	13	1	28 5
Miscellaneous industries and services .	1,040	3 3	11
Clerical, Sales and Kindred Workers . .	27	1	(5)
Bookkeepers, accountants, cashiers and ticket agents	19	1	28 5
Secretaries, stenographers and typists	6	02	33
Other clerical and kindred workers . .	2	006	36
Protective Service Workers	515	1 7	(3)
Policemen, sheriffs and marshals	4	012	34
Soldiers, sailors, marines and coast guards . .	541	1 7	15
Total	31,454	100 0	

* Occupational classifications follow *Classified Index of Occupations*, and *Alphabetical Index of Occupations and Industries*, Washington, 1940

The situation in some other countries is similar to that in the United States. Data for Germany, Denmark, Japan and India are given in Table VI. There are marked differences between these countries, Germany having a larger proportion of persons in the mental sciences than in any of the four other comprehensive fields, but for the other countries most prominent persons are found in practical vocations In Germany the arts were far more important than in the other countries, twice as important as in Denmark, about 29 times as important as in Japan, and about 23 times as important as in India. In Japan practical life embraced more than 60 per cent of all prominent persons, and in India more than 56 per cent were in administration alone. In Japan commerce was the most important single occupation, followed, very significantly, by military affairs; in Denmark the most important occupation was administration, with military affairs also ranking second; in Germany literature was the leading vocation, followed by medicine

Germany and Denmark had a fairly similar distribution, and that of India resembles that of Japan Thus the two European countries were quite similar, as were the two Asiatic empires, but the Asiatic and European countries were quite different This fact may be due to some extent to the manner of selection of the persons in the respective lists, which may be under different auspices in different countries and used for different purposes But a large part of the difference is a function of the difference between cultures and social organizations This is particularly marked in the case of Japan, with its emphasis on commerce, military affairs and administration and its small interest in the arts, in philosophy and in various intellectual and scientific professions so important in Europe and America

The distribution for the United States, to the extent that the lists are comparable, resembles those of Germany and Denmark more closely than it does those of Asia. The outstanding differences

TABLE VI

OCCUPATIONAL DISTRIBUTION OF PROMINENT PERSONS IN GERMANY, DENMARK, JAPAN AND INDIA DURING THE DECADE 1920–1930*

Occupation	Germany		Denmark		Japan		India	
	Per cent	Rank	Per cent	Rank	Per cent	Rank	Per cent.	Rank
Art	23 99	3	12 28	4	85	5	1 03	5
Painting	6 29	1	3 85	9 5	.35	20 5	....	...
Sculpture	1 18	24	1 12	21	.05	28.5	....	...
Architecture	1 50	19	1 75	17	05	28 5	.16	21
Music	4 92	9	2 94	13	23	22 5	60	11
Literature	8 10	2	2 62	14	17	25 5	27	16 5
Mental Science	32 09	1	21 96	2	15 13	2	12 57	2
Theology	5 53	5	3 85	9 5	41	16	16	21
Law	5 07	7	7 94	6	6 81	5	6 21	3
Philosophy	1 77	18	21	30	41	18	27	16 5
Philology	4 83	10	1 22	19	47	16	2 25	9
Pedagogy	3 68	11	5 60	7	5 03	6	2 97	6
History	6 55	4	1 54	18	.71	14	11	23 5
Mathematics	96	27	45	25 5	17	25 5	16	21
Political Economy	2 70	16	1 15	20	1 12	13	.44	13
Natural Science	17 99	4	20 04	3	14 71	3	6 98	3
Medicine	7 54	3	8 68	4	7 64	4	2 75	6
Cosmology	1 06	25	49	24	17	25 5	...	...
Chemistry	2.12	17	1 05	22	41	18	05	26 5
Physics	1 33	22	38	28 5	17	25 5	11	23 5
Mineralogy	1 21	23	42	27	1 30	11 5	....	.
Zoology	90	29 5	38	28 5	23	22 5	....	...
Botany	04	28	56	23				. .
Agriculture	2 90	14	8 08	5	4 79	7 5	2 07	4
Technology	1 55	5	2 69	5	4 79	4	3 46	4
Construction	1 35	21	2 59	15	4 79	7 5	3 41	5
Smelting	20	32	10	31		..	05	25 5
Practical Life	24 38	2	43 03	1	64 52	1	76 06	1
Administration	4 98	8	10 31	1	13 98	3	56 16	1
Politics	3 21	13	3 22	12	4 73	9	13 64	2
Military affairs	3 43	12	9 30	2	15 52	2	2 80	7
Crafts	67	31	2 55	16	59	15		...
Commerce	2 87	15	9 26	3	24 38	1	1 76	10
Industry	90	29 5	3 43	11	3 67	10	22	18 5
Publicity	5 74	6	4 51	8	1 30	11 5	33	15
Geography, Exploration	1 40	20	45	25 5		.	22	18 5
Organization, Propaganda	1 02	26		.	35	20 5	.55	12
Miscellaneous	16	33	. .	.		..	38	14

* Giese, *op. cit*, pp 14, 236

between the United States and German distributions are in the arts, military affairs and agriculture, where the German proportions were larger; and in law and religion, where the United States stands out The United States resembles Denmark in art, is far behind in agriculture and military affairs, and far ahead in religion and law. In many of the specific mental and natural sciences no direct comparisons are possible, because of the classification employed for the United States. College and university education overlaps on these scholarly professions to such an extent that the distributions for Germany and Denmark may well resemble that of the United States, but India and Japan lag in everything except practical vocations, in only a few of which they are heavily represented.

CHANCES FOR EMINENCE IN EACH OCCUPATION

The data on occupational distribution of prominent persons are not very significant unless the occupational distribution of the total population is also taken into consideration. Although the matter has received some attention,[6] numerous obstacles stand in the way of comparing eminent men and the general population in regard to occupational distribution.

[6] *Cf.* Giese, *op. cit.*, pp. 87–92.

In the first place, it is impossible to obtain reliable occupational distributions for past historical periods Secondly, there is little agreement between existing classifications of occupations of eminent persons and those of the general population, except where parallel categories are deliberately used. And if very crude classifications are used for both the general population and the list of prominent persons, the results are rather meaningless. Again, the inclusion of all classes of people in the same general occupation does not give a correct impression of the chances for eminence of an individual in the more responsible and influential administrative positions in the general field For example, almost all the persons listed in "Who's Who in America" from the field of transportation are from the highest administrative and executive levels, and it is a question if all persons employed in transportation should be compared with these selected persons from a selected part of the total group gainfully employed in transportation. What needs to be done is to have both the general and the most socially recognized populations classified according to the same functional classification, each class being determined by the general social function and by the specific contribution to the general social function It would also be advisable to base the inclusiveness of the general functional groups upon the chances for each individual to climb into the most favored circles (administration and ownership) of the general functional group of which he is a member.

The available data from published studies are far short of this ideal. Only the crudest sort of comparisons can be made for the occupations of historical personages. Philosophy stands out more than any other profession in the production of the most illustrious persons of history, since there have been few professional philosophers and philosophical writers. Of the relatively small number of persons in this profession during the period of history, a relatively large proportion have attained the very greatest fame. Writers and scientists also stand out historically, as do rulers, artists and musicians. The religious vocation is not heavily represented, according to its numbers, although the most eminent personages include a high proportion of religious founders and reformers Engineering also does not seem to have provided many eminent personages in proportion to the number of people engaged in such pursuits during the development of advanced civilizations. But most striking is the tremendous inferiority of the occupations that make up the bulk of the population in other historical periods—craftsmen and artisans, personal and domestic servants, tradesmen, farmers and peasants and other manual laborers

Among famous women of history the vocation of literature is of very great importance, and sovereignty is about equal to it Indeed, sovereignty stands alone in the lead, if we consider that few women who were sovereigns in their own right have appeared in history. Acting, music, scholarship and art also have provided outstanding opportunities for fame In religion women seem to have a proportionately better record than men, since the traditional role of women in most societies has kept them from positions of leadership

In general, Maas's data for Germany bear out the same conclusions.[7] The arts and the intellectual vocations obviously surpass the practical vocations in per capita production of prominent persons, when we consider the number of people working in various vocations. And of the practical vocations, statesmen have an advantage; but agriculturists, military men and merchants are at a severe disadvantage, and craftsmen, artisans, industrial workers, miners, fish-

[7] *Cf.* Table IV.

TABLE VII

NUMBER OF PERSONS LISTED IN "WHO'S WHO IN AMERICA, 1938–39" PER MILLION OF EMPLOYED POPULATION, 14 YEARS OLD AND OVER, 1940

Occupational Class	Number of persons in "Who's Who in America, 1938–39"*	Number of persons 14 years old and over employed 1940†	Number in "Who's Who in America" per 1,000,000 of the employed population	Rank order
Professional and Semiprofessional Workers	24 626	3,345,048	7,361 9	(1)
Professional	24,284	2,881,594	8,427 3	((1))
Actors	155	11,692	13,256 9	6
Architects	253	19,899	12,714 2	7
Artists and art teachers	900	51,985	17,312 7	5
Authors, editors and reporters	4,388	70,059	62,632 9	2
Chemists, assayers, metallurgists	124	55,371	2,239 4	18
Clergymen	3,006	133,449	22,525 5	3
College presidents, professors and instructors	4,996	75,007	66,605 3	1
Dentists	30	71,414‡	420 1	27
Engineers	1,165	244,558	4,763 7	13
Lawyers and judges	3,552	177,643	19,995 2	4
Musicians and music teachers	679	129,256	5,253 1	12
Osteopaths	13	5,071‡	256 4	29
Pharmacists	2	78,709‡	25 4	32
Physicians and surgeons	2,090	164,649	12,693 7	8
Social and welfare workers	145	69,677	2,081 0	20
Teachers (not elsewhere classified)	1,333	1,030,001	1,294 2	22
Trained nurses	2	355,786	5 6	36
Veterinarians	27	10,998‡	2,455 0	16
Other professional workers	1,424	126,370	11,268 5	9
Semiprofessional Workers	312	463,454	737 0	((2))
Dancers, showmen and athletes	20	31,147	642 1	24
Designers and draftsmen	10	100,925	396 3	28
Other semiprofessional workers	282	331,382	851 0	23
Farmers and Farm Managers	132	5,143,014	25 7	(4)
Proprietors, Managers and Officials, Except Farm	6,124	3,749,287	1,633 4	(2)
Government officials	2,060	198,377	10,384 3	10
Other specified managers and officials	230	115,468	553 6	25
Proprietors managers and officials, not otherwise classified, by industry				
Mining	119	30,447	3,908 4	14
Construction	50	113,898	439 0	26
Manufacturing	838	419,891	1,995 8	21
Transportation, communication and utilities	290	134,232	2,160 4	19
Trade	211	1,704,189	123 8	30
Finance insurance and real estate	1,273	174,668	7,288 1	11
Personal service	13	123,227	105 5	31
Miscellaneous industries and services	1,040	434,890	2,391 4	17
Clerical, Sales and Kindred Workers	27	7,517,630	3 6	(5)
Bookkeepers, accountants, cashiers and ticket agents	19	895,965	21 2	34
Secretaries, stenographers and typists	6	1,056,886	5 7	35
Other clerical and kindred workers	2	5,564,779	4	37
Protective Service Workers	545	681,534	799 7	(3)
Policemen, sheriffs and marshals	4	169,512	23 6	33
Soldiers, sailors, marines and coast guards	541	219,925	2,459 9	15
Other protective service workers	..	292,097	..	38
Total	31,454	20,437,113	1,539 1	..
Grand Total	31,454	45 166,083¶	696 4	..

* Source Table V

† Source "Occupations of Persons 14 Years Old and Over in the Labor Force, for the United States, 1940" Series P-11 Summary of Sixteenth Census, June 19, 1942 Only employed workers (except emergency work) included in this table

‡ Female workers for the group "osteopaths, pharmacists, dentists and veterinarians" distributed according to the same proportions of male workers in these professions

¶ Total employed workers (except emergency work). *Cf* footnote †, this table

ermen and domestic and personal servants have practically no chances for eminence—that is, of course, provided they do not shift into occupations offering more opportunities for highest social recognition.

In the case of prominent contemporary Americans our knowledge is now much

more complete. Table VII contains the rates per million population, 1940, for the appearance of different vocational groups in the "Who's Who in America" list, 1938–39. This table also includes relative productivity for some industry types as derived from ratios. The professional services dominate, followed by proprietorial workers and protective service workers. Agriculture has a very unfavorable position, and clerical occupations lagged even farther behind the professional group Domestic service workers, craftsmen, operatives and laborers contributed no prominent persons, and consequently they are absolutely inferior to any other groups in providing opportunities for national recognition

The detailed occupational breakdown of Table VII provides data on chances for eminence by specific occupations Subdivisions of clerical, sales and kindred workers remain as the most unfavorable vocations appearing in the list Other clerical and kindred workers exhibited the lowest per capita position in the list, followed, in order, by trained nurses, secretaries, stenographers and typists; bookkeepers, accountants, cashiers and ticket agents, policemen, sheriffs and marshals; pharmacists; and farmers and farm managers.

Among the proprietorial group government officials stand at the top, followed by the finance group, and then by mining; miscellaneous, transportation, communication and utilities; and manufacturing proprietors, in order. The lowest proprietorial group was personal service (for example, hotel and lodging house keepers, and proprietors of laundry and dry-cleaning establishments), followed by trade proprietors The position of the former is probably due to the low prestige of the work, while a combination of low prestige and the immense number of kinds of retail business proprietors in the country probably explains the latter.

The highest occupational positions, as would be expected from a review of the analysis of the industry groups, are among the professions, with higher education surpassing authorship-editorship by a relatively small margin. These two occupations are far ahead of all others in providing chances for social recognition, but persons engaged in such vocations as law, art, acting, architecture and medicine are ahead of all other occupations Somewhat superior to trained nurses and pharmacists, who have fewer opportunities than the other professional groups, are osteopaths; dentists, and chemists, assayers and metallurgists Also comparatively low in position are the bulk of the educators (elementary and secondary school superintendents, principals and teachers) and social welfare workers Musicians and engineers stand in a position somewhat below the average for the professional group but higher than any of the nonprofessional classes, except government officials and financiers The various semi-professional groups surpass many of the different specific occupations mentioned, although ranking considerably below the professional and proprietorial groups.

Protective service workers, as a group, also surpass the semi-professional workers by a small margin But military leadership shows up fairly well in terms of the whole list. Its position is immediately above that of veterinarians, and below that of mining proprietors and engineers. It will be of considerable interest to observe the extent to which the trend of events during the war will have an effect on the number and relative importance of the military group According to the policy of the editors of "Who's Who in America" in the past, all army officers above the rank of colonel, and corresponding officers in other services, are invited to send sketches for inclusion in the list. As the armed forces expand in

size the number of higher officers must necessarily increase and the military profession will thus tend to contribute a much higher percentage to the list as a whole. But this might not improve the chances for each military man to receive national recognition, since the standards for inclusion might be left unchanged or raised, or the proportion of general officers to all military men might change as the country is more fully converted to a war status.

The tendency for the professional occupations to offer the most chances for eminence has also been found true of Germany, and similar conditions probably hold in other countries. Agriculture offered few chances, in the case of Germany being at the bottom of the list, surpassed by persons engaged in crafts. Manufacturing and business were comparatively low in rank, but ahead of agriculture. Authorship and painting and sculpture stood out above all other occupations, with painting and sculpture leading This is not characteristic of other countries concerning which we are able to draw conclusions. In Germany law ranked ahead of medicine, music, religion and the other intellectual and scientific professions, which offered few chances because of the large numbers of people engaged in them.[8]

Notwithstanding some differences between the sexes and between countries, it is apparent that there are rather uniformly superior chances for recognition for persons in the professional occupations, followed in order by government and military affairs, business, agriculture and the clerical occupations, while other occupations offer practically no chances for eminence for the average individual who remains within them.

Few data have been published on the relative contribution to a list of prominent persons made by the various strata within each occupation or industry. It is known that only the superior levels of any occupation are represented among the most outstanding persons. It is illogical that a person of inferior position in an occupation should attain social recognition that has not been accorded to all persons whose positions are superior to his. In fact, only when recognition entirely rests on other things than intraoccupational status—which it only rarely does, as in the case of notorious persons—may people obtain recognition out of relationship to their wealth, authority, power to control other people or the supposed value of their contribution to society, which can never be greater than that of their superiors

Differences in intraoccupational prestige are sharply defined and they influence social position far beyond the limits of the occupations in which they are found. A person, as representative of an occupation, can only with the greatest difficulty escape the implications of his position within the occupation The conditions growing out of differences in status of persons of different intraoccupational strata also help to explain the small number of representatives of certain fields among lists of eminent persons, and particularly the small per capita contribution of some fields. In general those occupations that have the most rigid and the tallest hierarchy of classes, and in which the largest proportion of persons are of inferior status, are less productive of eminent persons than are the other fields, if production is considered in relation to total population. This is particularly true of mining, manufacturing, transportation and commerce It is also more true in education than in some other fields of professional service. The most prominent exception to the principle is agriculture, but even here the proportion of laborers is large. Farmers are severely handi-

[8] Based on a comparison of the distribution of the "Wer Ists?" cases studied by Giese and the distribution of occupations in Germany. Giese, *op. cit*, p 20.

capped by reason of their place of residence and the urban point of view in the evaluation of social worth, so that the factor of class hierarchy is not needed to explain the disadvantages of the farmer. Proprietorship in agriculture is certainly not a parallel phenomenon to proprietorship in most urban occupations, because it often is not concerned with the planning and management of organizations involving large numbers of employed persons per manager and proprietor. If the data for farmers could be corrected for those items in which agriculture differs from other occupations, the importance of the structure of the intraoccupational pyramid would probably be borne out in agriculture as it is in other occupations.

Occupational Prestige and Per Capita Production of Eminent Persons

There is, no doubt, a close correlation between the accepted ideas of superior social status of occupations and the prevalence of persons of various occupational groups among prominent people. An absence of representatives of the occupations of lowest prestige is particularly noteworthy, while occupations close to the top of the occupational hierarchy are relatively well represented in lists of prominent persons The closeness of correlation, however, is not easily measured for historical personages, because of the lack of similarity of judgments of status over the entire period of history and over the entire region embraced in the studies of eminent persons made by Cattell and Castle. We know, for example, that poets had inferior status to that of statesmen, theologians and generals in past ages, even as they have less general social influence and power to-day, although the prestige of poets has varied in reference to other occupations from time to time and place to place. The same thing is true of other occupations, so that the only completely satisfactory kind of evidence on the relationship between prestige and production of eminent men must take into consideration both the production of prominent personages by each occupational group and objective information on occupational prestige for the same time and place.

Although a satisfactory standard of evidence is impossible to obtain for historically eminent persons, there is considerably more certainty for contemporary leaders There is, for example, close agreement between the results of available data on occupational status and the ranking of per capita production of eminent men by the main classes of occupations listed in Table VII. Although there is incomplete agreement among available studies[9] of occupational prestige with reference to the subdivisions of the main occupational classes, the professions are at the top in prestige and per capita production of eminent personages, followed closely by business proprietors Farmers lag behind these two, as they do in the production of leaders Clerical, sales and kindred workers also are distinctly below professional and proprietorial workers in prestige ratings; but both farmers and clerical, sales and kindred workers surpass skilled workers, factory operatives, and personal service and unskilled workers The similarity of occupations in prestige and productivity of leaders, therefore, is probably at least as close as that represented by a correlation coefficient of .70, which is among the higher class of coefficients for social data.

The correlation between production of leaders by an occupational group and the prestige of the workers in that occu-

[9] G. S. Counts, *School Review*, 33: 16–27, 1925; and W. A. Anderson, *Journal of Social Psychology*, 5: 435–466, 1934 Unpublished data from a more extensive study of occupations made by the author also support the statements in the text.

pational class is without doubt a causal one. The prestige of certain occupations increases the chances for the representatives to be included in the list of leaders, and the fact that people in certain occupations obtain recognition in such biographical directories, in the press and in other ways influences the opinions of people concerning the importance of the occupations Even when opinions concerning the importance of occupations are not influenced by knowledge of the "Who's Who in America" occupational classification, they are conditioned by the same general sort of knowledge of leadership on an occupational basis, as is possessed by persons who suggest the names of leaders to the editors of biographical directories and by the editors themselves

Summary

Our knowledge of the occupational status of leaders is fairly complete in some respects[10] It is known that those who are historically eminent have a different occupational distribution from that of contemporary eminent persons, and that there are sex differences in occupational distribution of notable personages Persons in the practical sphere, statesmen, rulers and military men are proportionately more numerous among the historically great than among contemporary western peoples, while eminent men from the intellectual and artistic spheres are proportionately more numerous to-day than in past times Eminent women in all ages have been proportionately more prominent in literature than elsewhere, in intellectual and artistic pursuits than in practical ones, and in intellectual and artistic pursuits than have eminent men. There is also considerable agreement between the occupational distribution of contemporary eminent persons in various Western European countries, especially with regard to the main types of occupation, but there are pronounced differences between Asiatic and European countries.

The professions again lead all the large occupational classes in the relation of the "Who's Who in America" occupational population to the general employed population Political and military affairs also show up well, as do several business proprietorial occupations, but other vocational fields reveal comparatively few opportunities for eminence. Clerical occupations are at a very serious disadvantage. Agriculture shows up only slightly better. University administration and teaching is the most favorable field for contemporary American recognition, followed by literature, religion, art and law. Other professions rank very well also, while at the other extreme personal and domestic service, skilled craftsmen, foremen, machine operatives and various unskilled labor occupations offer practically no chances for social recognition.

Only the superior classes in each occupation are represented among the most prominent people, but less important leaders include a few persons of somewhat lower intraoccupational status. So far as our knowledge goes, there is close agreement between the judgments of superiority of occupational status and the occupational distribution of prominent persons. Few of these conclusions are reliably supported and none is so certain or detailed that no other investigations need to be conducted. However, the problems are fairly well defined now, and, since the required methods of study are well known, it may be hoped that more complete evidence will soon be made available.

[10] See a somewhat similar condensation in Mapheus Smith, *Scientific Monthly*, 48: 560, 1939

THEORY AND SCIENTIFIC DEVELOPMENT

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WHAT is the role of theory in the development of science? To-day one is strongly urged to say it is to *make things work* For we are engaged in the tasks of building guns, tanks, planes and other war-needed appliances We are involved in the *grim* business of science But there is a peculiar paradox in this situation scientists give this pragmatic answer, theories are designed to make things work, with the fond hope in their hearts that some day they will be permitted to deny it; they shift emphasis from the precious and permanent aspects of their subject matter to its coarser features in order to fight a war that will bring about conditions favorable to the pursuit of a science which is *free* from utilitarian bonds

If, therefore, I place the question of the role of theory in a larger setting, ignoring the necessary platitudes of the day, I am envisaging a post-war world I am focusing attention upon an ideal which we are approaching, and I hope that, in perceiving its clean and lofty features on a distant horizon, we may draw the strength to conduct the grim business of science with greater vigor to-day.

There is, perhaps, another sense in which the answer I should like to give is needed in a world at war Science has been accused of having fostered the taste for material things, of having made the murderous instruments of modern war. It has been alleged to possess no cultural value, and its emphasis upon power is said to have led to the present crisis It is true that without theoretical science our wars would be less horrid, but it is also true that if the scientific attitude were to prevail generally, no wars would be fought As to the argument, however, that science is devoid of cultural value or appeal, I believe it is utterly false. Theoretical science is linked far more closely with philosophy and even the more highly developed of the social disciplines than is commonly supposed These somewhat cryptic statements I hope to clarify The following remarks are intended to show what it is that distinguishes *knowledge based on theory* from *empirical knowledge* based solely on fact

First of all, let us observe theory in action There is evidence that four thousand years ago Egyptian surveyors used in their work a bit of knowledge very much akin to the Pythagorean theorem They called it the three-four-five rule and used it to determine the third side of a certain right triangle when the other two sides were known The rule was gleaned from painstaking and accurate observations and was fertile in its use The knowledge which it represents was not based on theory · It blossomed into a theory when Pythagoras, the Greek, gave his famous proof [1] The problem to be analyzed here concerns the details of *what happened* when that (or any other) theory was born

Consider another example During the 17th and 18th centuries a useful synthesis of chemical knowledge was effected under an hypothesis which we will call the *phlogiston rule* It developed as the result of wide and careful observations on combustion and brought forth the thesis that every combustible substance

[1] To be historically accurate one should concede the possibility of an anticipation of this proof by the Babylonians, but this does not matter here.

is a combination of its calx (ash) and a universal fiery principle called the phlogiston. The rule was obviously chosen to fit the visible phenomena. It was not a theory in the restricted sense in which we desire here to use that word, notwithstanding current terminology which sanctions the phrase "phlogiston theory." It was a deeper insight into matters, not solely based on observation, which, toward the end of the 18th century, caused Lavoisier to propose a *theory of combustion,* a body of propositions which can properly be called a theory in the modern sense.

To these two instances drawn from mathematics and chemistry, we add a third, illustrating the birth of a theory in modern physics. In 1885 Balmer proposed a simple formula which represented adequately and with striking precision the frequency of all spectral lines of hydrogen. His rule amounted to a beautiful synthesis of a large part of spectroscopic knowledge, but it lacked that element of metaphysical fitness, usually expressed by saying "it explains," which would have made the rule a theory. This element was added by Bohr when, in 1913, he published his work on the hydrogen atom. In what respects was our understanding deepened when this theory, or any other, came into being? I shall first review and criticize some current attitudes toward this problem

Economy of Thought

According to Mach, theories spring from a tendency which he terms "economy of thought" Mental effort is saved, he claims, memory is facilitated, associations between facts are more easily established, if perceptions are embedded in a rational framework. To quote him:[2] "The aim of natural science is to obtain connections among phenomena. Theories, however, are like withered leaves, which drop off after having enabled the organism of science to breathe for a time." The implication is, then, that science can live without breathing.

If this thesis is meant as a factual assertion, its truth can well be denied by reference to the observation that there is no universal urge toward economy of thought among scientists, or, indeed, anywhere among literate people; and that if there were such an urge, there would certainly be no science.

Psychologically, an effort to economize on thought is painful rather than pleasant, notwithstanding the cynical professor whose experience would seem to contravert this statement. For it is not the question whether thought is painful when it is enforced on matters of indifference to the thinker, but on matters of intense interest; for we may certainly presume that a scientist is interested in his field. If theories gratify because they conserve thought, then it is hard to see why thought-provoking utterances are generally held to be of greater value than uninspiring ones. No, the purpose served by theories is not to promote languor, but to key the mind for thought. Quite aside, however, from the psychology of the situation (which, I believe, provides a negative answer to the question "does the scientist strive for economy of thought?") suppose we were to accept an affirmative one. Science would then appear as a blight on the tranquil face of nature, the scientist as a scourge with which the devil harasses serenely thoughtless men. In fact, science, if it had ever started, would long be extinct.

But Mach's statements are hardly to be taken as positive and analyzable assertions; they aim, as do so many modern philosophical writings, to establish a point of view and not a system, to confer emphasis and not validity. It is perhaps more proper to formulate Mach's position in a more elaborate way: Economy

[2] *Die Geschichte und die Wurzel des Satzes von der Erhaltung der Arbeit,* 1871.

of thought is to be coupled with a desire to dominate an ever increasing set of facts, or sense impressions. It is obvious, one might claim, that man's natural tendency is to learn more and more about nature, for it is by controlling her that he may emerge from his primitive cave, ride the waves, cook his meat, drive his automobile and enjoy all the other comforts of civilization Curiously enough, however, man does not like to think, or tax his memory beyond necessity, and thus he invents devices called theories which serve as receptacles for facts.

The fields of medicine, geography, botany, zoology abound with factual knowledge without theories to correlate them I doubt very much whether in physics or mathematics, two sciences replete with theories, more facts are known than in the aforementioned disciplines. The difference is of quite another sort: theories bestow on facts a peculiar relatedness which is far from being exhausted by the quality of mere associative coherence When a theory is shown to be wrong it is discarded and another one is put in its place: Were its purpose only to facilitate memory such a procedure would be absurd; it would be far simpler to retain the theory and learn the one fact contradicting it as an exception. Finally, even in science we distinguish rules from theories. The former are devices aiding memory, but not the latter. To summarize, then, suppose we admit that we wish to dominate nature, and wish to do this with a minimum of thought; in that case *theories* would not be the answer to our wishes.

Why, then, has Mach's slogan of "economy of thought" been so effective, and why is it extolled even to-day as the sinecure of all philosophical afflictions torturing the physicist? One reason is certainly to be found in the soporific nature of the doctrine. The answer it gives is so easy, and once it is accepted, economy of thought prevents all further scrutiny which might otherwise refute it. To use another metaphor, the thesis of economy of thought has all the features of a chain reaction: as soon as it is started it produces favorable conditions for its own rapid propagation.

But let us not push this travesty too far, for it provides only a partial reason for the prevalence and the persistence of Mach's idea. It is to be acknowledged that it contains an element of truth. A theory, in order to be valid, must be *simple* in a sense to be clarified later. Of two theories, both of which are equally compatible with experimental facts, the scientist retains the one which involves the smaller number of unrelated concepts. As a case in point we recall the rivalry between the Ptolemaic geocentric and the Copernican heliocentric system of astronomy which lasted throughout the 16th and part of the 17th centuries. Copernicus' essential claim was that his hypothesis required the use of fewer independent assumptions (epicycles and deferents) than did the other. Both described the motion of the stars with equal accuracy. It was on the basis of its simplicity that the heliocentric system was finally adopted. A similar situation arose in connection with the elastic solid theory of the ether; it, too, was rejected chiefly because it became unwieldy. There is undoubtedly a significant contact between such simplicity and economy of thought, a contact which Mach would regard as the essence of the matter. Unfortunately, however, simplicity is not the only criterion for the validity of theories, nor is it the most important.

Prediction

According to one view widely held at present the function of theory is *prediction of events;* indeed, facility of prediction is often regarded as the sole, or at any rate, the most important, purpose of theoretical procedures. It will not be denied that theories permit pre-

diction in ever increasing measure, and that the practical value of a science largely resides in this circumstance. Hence whatever conclusion we shall finally reach in regard to the essential role of theory, it must account for its predictive power. But to *identify* bluntly the business of analytical investigation with prediction is not only arbitrary but misleading.

For there are, and have been, many theories which failed to predict What Pythagoras added to the 3-4-5 rule of the Egyptians was not principally an element conducive to the discovery of further facts: it was an internal relation between facts already known, a feature far more elusive than power to predict. Lavoisier's discovery, to be sure, did lead to the important assertion, verified by experiment, that the total mass is conserved in combustion. Again, the theory of Bohr can hardly be said to have led to essential empirical results other than those already implied in Balmer's rule.

We conclude that prediction, or the acquisition of facilities for prediction, does not exhaust the meaning or the purpose of theory The scientist need not turn prophet, nor would a successful prophet, if he did exist, be of necessity a scientist. The latter's task involves something more than mere forecasting, it involves the creation of a certain scheme in which his experience becomes peculiarly coherent, the production of an internal fitness which power to predict alone does not convey In fact, one could name fields in modern physics where experimental facts are confusingly abundant, and where investigators would be immensely grateful for a valid theory even though it did no more than order known facts.

Theories are sometimes called beautiful or elegant. This esthetic property is ascribed to them wholly apart from their pragmatic value, indeed occasionally when they lack pragmatic value. Every scientist has an instinctive appreciation of this quality of beauty. It is often the motive for intensive research; its achievement produces a pleasure unique in itself and not peculiar to the act of prediction, a pleasure that is present to a lesser degree whenever a problem is solved. Thus it is clear that, from a psychological point of view, the driving force in theoretical investigation is not exclusively the *fun or the profit* of prediction.

Realism

A third point of view which was widely held half a century ago, and which is not completely extinct today, is that of realism According to this doctrine theories portray reality. There is an objective essence, external to the mind, but waiting to be grasped and understood by the human intellect There can never be an ambiguity in theory, for a theory either represents or does not represent real fact. Scientific investigation, both in its experimental and analytical aspects, is always discovery, never invention.

Toward the end of the last century realism, even in its more accentuated form of materialism, was a highly plausible philosophy Helmholtz had shown in his brilliant lecture before the Philosophical Society in Berlin (1847) how the most general laws of physics can be derived from two simple hypotheses: (a) everything consists of point particles subject to the laws of motion; (b) all particles are subject to central forces. Clearly, then, if all empirical knowledge can be synthesized in these two general propositions, how can anyone doubt their truth? And if everything consists, in fact, of material points, how can the externality and independence of nature be denied? Explanation can not be a fictive process, it effects merely illumination of entities already given.

But alas, the two great premises of Helmholtz were shattered by science itself; they became untenable even before the century expired. Significant elements of physical "reality" were discovered which were not particles, but fields, and particles were discovered which did not interact by central forces. Explanatory procedures took on a character so abstract that their results appeared very much more like inventions than discoveries And the hope gradually faded that it would ever be otherwise. The much discussed dualism between the wave and particle properties of light left realism completely powerless Recognition of the fact that it is dangerous and misleading to ascribe to ultimate particles like an electron such properties as shape, size or exact position struck realism a decisive blow. There are few thinking people who still believe that an electron is an entity in the same class as this perceived desk before me.

It may be said that science has merely confirmed a fundamental criticism which semantic analysis could have made perhaps without the aid of science. For the trouble with the term realism is its superabundance of meaning coupled with its magic sound. Reference to what is *real* is expected to silence all argument Yet there is no other word in the English language which is so ill-defined. When I speak of the reality of this desk and of the reality of the war I am using the term with two quite different connotations. It is easy to cite half a dozen others. The only person not guilty of looseness when he uses the word is the mathematician who speaks of real variables, but his meaning is philosophically uninteresting. After some thought on the matter I have come to believe that an analysis of the role of theory has a far better chance of succeeding if the word reality is banned from the discussion, unless it be clearly defined beforehand. At any rate, let us not permit the word *real* to hypnotize us into uncritical acceptance of a point of view which modern physical science has outgrown.

What is Physical Explanation?

The terms in which physical explanation is to be defined depend very largely on one's philosophical outlook It is necessary, therefore, that I comment briefly on the epistemological background of the remarks to follow [3] This happens to be somewhat out of adjustment with the views professed by the most prolific writers on the philosophy of science, chiefly because of the failure, on this author's part, to espouse whole-heartedly the neopositivistic doctrine It is my belief that metaphysics can never be completely banished from exact scientific procedures, that no guarantee for permanence of a scientific theory can be gained by basing it on *facts* which, when analyzed, reveal a most bewildering array of metaphysical assumptions Instead of closing our eyes to metaphysics and allowing it to go without control, as seems to be the current fashion, it is important that its action in modern theory be first recognized, then analyzed and harnessed for better or for worse

Extreme positivism, culminating in the belief that all science is restricted to an analysis of sense data, is invalidated by all of theoretical physics; but nowhere is its weakness so glaringly exposed as in the recent development of quantum mechanics. Only a remnant of the positivistic doctrine has crept into the credo of modern science: it is Kant's dictum that *"Erkenntnis ohne Anschauung ist leer."* To this maxim we shall adhere.

Admitting, then, that the scientist does not deal exclusively with sense data, such as colors, shapes, noises, smells, and pointer readings, let us at once divide his universe of discourse into two classes

[3] For a more extensive exposition see: H. Margenau, *Journal of Phil. of Science*, 2: 164, 1935; 6: 65, 1939; *Rev. of Mod. Physics*, 13: 176, 1941.

of things: *sense data* and *constructs*. The latter are concepts invented by rules to be mentioned later, which bear certain invariable relations to sense data, but are not themselves immediately given. Thus a certain wavelength of light is a construct associated with the (complex of) datum "blue." Other constructs are: number, integral, space, in mathematics; element, compound, valence bond, in chemistry; mass, electric field, electron, in physics. This list could be extended indefinitely; in fact, closer analysis shows that all scientifically interesting objects are constructs rather than data.

If now the role of theoretical science is to be described succinctly the following must be said: In the first place we have sense awareness. The elements of this awareness, while peculiarly vivid, spontaneous and ever-emergent, lack all attributes which allow analytic procedures amongst them, and hence do not lend themselves readily to being dominated by reason. Hence constructs are invented in such a way that (a) they stand in unique correspondence with sense data which they represent symbolically; (b) they partake of properties which make them subject to the procedures of logic and mathematics. Having translated a particular set of data into constructs, the scientist transforms these constructs, within the context of a particular theory, into others by logical and mathematical rules. He then translates the new constructs back into sense data and sees whether these, under the conditions implied by the theory, are found to be present. If so, he says that he has verified the theory (a set of constructs connected by "laws") in this particular instance; if not, the theory (or hypothesis) is discarded as not valid. A theory is said to be correct if it permits this peculiar circuit, which starts somewhere in the esthetic continuum among sense perceptions, swings into the field of constructs and finally returns to the esthetic continuum, successfully hitting its mark; indeed, if it permits this circuit to be made without fail in all cases to which the theory has relevance.

This brief characterization will, I hope, sufficiently outline my point of view. I shall forego the opportunity of giving evidence for its correctness, chiefly because the field in which it could be tested and exemplified is extremely wide, embracing all of science. It is possible to classify the constructs used in any given science, to state the rules of correspondence between data and constructs (these are often the so-called "operational definitions") and finally to analyze the relations connecting constructs into theories. But these details must not detain us here.

Metaphysics

A construct is not a part of sense data; it is not immediately given. On the contrary, it is an entity generated by creative reason and as such not fundamentally different from the abstract notions of philosophy and theology. The difference between scientific constructs and the latter lies in this remarkable circumstance: in the selection of valid scientific constructs certain rules or requirements are being imposed which are more stringent than, or at any rate different from, those which attend the choice of non-scientific constructs. Again these rules, often dimly perceived by the philosophers of the past and regarded as invariable "categories" of thought, are not drawn from sensory experience but are strongly founded in deep-rooted conventions among scientists. An analysis of these rules, whose aggregate I shall call metaphysics because they transcend by far the domain of sensory experience, is to be the object of the present section. Metaphysics, then, as the term is here employed, does not include its traditional branch, ontology; it is simply the epistemology or, more properly, the methodology of science.

To make clear the distinctions to which attention is being called it is necessary to guard against a widespread confusion occasioned by the imperfections of language. Single words are often used to designate essentially different things. Thus in the phrase. I feel the mass of a chair when I push against it, the word mass is being used to denote a complex of sense data. The mass which appears in Newton's laws of motion is quite another entity and must not be identified logically with the former. It is to be sure, linked to it by certain correspondences (operational "definition" of mass), but it stands as a construct, a rational invention the significance of which could meaningfully be denied, were it not for its unique conformity with certain metaphysical requirements which will now be outlined.

This list of comments that follows is meant to be suggestive rather than exhaustive Nor does it aspire to any pretense of logical demonstration which, if it could be carried out successfully, would exceed the confines of the present paper. If it is only provocative of thought, its purpose will have been achieved. My belief is that it covers the principal axioms of scientific methodology.

(a) All valid constructs must be *transitive* in the sense that it is possible to pass from one to another by logical or mathematical relations This type of transitivity allows constructs to be connected into theories. Furthermore, there must be *some* constructs (here called pseudo-sensible) which are operationally connected via the rules of correspondence mentioned in the foregoing section, with sense data. And finally, every construct, while not necessarily connected with all other constructs, must form a transitive link with at least one pseudo-sensible construct and hence with sense experience. Thus it need not be required that every construct should have a sensible counterpart. It is sufficient that it be transitively connected with a construct of the pseudo-sensible class.

(b) The passage from one construct to another is to be effected by the *laws of logic* and mathematics considered valid at the time. At present, these are the laws of two-valued logic, and the mathematical results based thereon. But there appears to be no reason to suppose that more general types of logic, which are now being developed, will not some day replace the familiar one. Nor is it to be argued that science must restrict its laws to the manipulation of such elementary mathematical notions as numbers and functions. Quantum theory shows, in fact, that this limitation is harmful.

(c) The correspondence once set up between data and constructs, must be *permanent*. This trivial requirement simply forbids that a symbol, such as mass or wavelength, be referred to the elements of sensory experience in an indiscriminate manner, violating the definitions.

(d) The relations among constructs are required to be *extensive*. I hasten to elucidate this unintelligible phrase by means of an example. Tradition has it that Newton saw the apple fall and in contemplation upon this phenomenon conceived the laws of motion. As an historical assertion this is certainly in error, but as an illustration it may serve. The sense data in this case are clear. By means of permanent rules of correspondence Newton arrived at the constructs mass, position, speed, acceleration. In modern parlance some of these were joined into a differential equation which Newton solved. To the solution he applied the same rules of correspondence, and these led to verified sense experiences. The circuit was completed.

But the situation would not have been satisfactory if Newton, after his excursion into the real of constructs, had been

able to predict only the position, speed, and acceleration of the apple at a single instant, namely its condition at the moment when he began reflecting. For in that case, he would have taken the same route back from constructs to data which originally led him from data to constructs This is the situation against which we desire to guard when we insist that the constructs must be extensive They must permit the return to sense experience on a different route than that taken originally into the realm of constructs. Moreover, they must land the investigator at a point in sense experience different from the starting point Thus, in the present example, this criterion was satisfied because Newton was able to predict position and velocity of the apple at a different time than when his original observation was made.

So far, the illustration adverts to the barest minimum of extension to be required among constructs But the scientist demands more Newton would have been dissatisfied if the formation he invented for this particular apple had not been valid for other apples, or indeed, for describing the motion of the moon It is extension of a set of constructs, or a theory, in this more general sense that forms the metaphysical requirement here under discussion.

Will the constructs of science ever be indefinitely extensive? Will there ever be one theory capable of explaining uniformly all phenomena? Many thoughtful investigations fervently affirm this theory, but their answer is given in prophetic anticipation of their fondest hope, and not in cool appraisal of present trends For there is at present less of a unifying tendency than in other periods of the history of science, and the universal extensibility of any theory may well be doubted I therefore favor to include in this list of metaphysical requirements, not universal extensibility, but any finite sort of extensibility at all.

(e) Perhaps the clearest and the most definite of the rules which valid theories satisfy is that of *causality*. Shorn of all technicalities, it amounts to this One selects certain constructs having "magnitude" and regards them as defining the state of some other construct called object, or system. The former are then fed as initial or boundary conditions into some mathematical formalism, usually a set of differential equations, and a solution is obtained. This solution is valid at other times or places; the method has served to *predict* in a very general sense Now when constructs can be selected so that this method is applicable, the theory containing them is called a causal one To obtain a causal theory it is not sufficient to discover a law; it is necessary first of all to discover the proper constructs which are symbolic of the empirical situation and which will permit the establishment of causal laws. The admirable feature in Galileo's contribution to physics was his recognition of *acceleration* as the significant construct in the description of freely falling bodies —discovery of the law was easy after that On the other hand, it is believed that the absence of causal laws in a large part of hydrodynamics continues not because such laws do not exist, but because the variables through which phenomena can be described causally have not been found.

It should be evident that causality is *not* a quality which adheres to sense impressions No one who is enmeshed in this basic fallacy can see how modern science functions. It is customary to say, of course, that the seen stroke of lightning is the cause of the heard thunderclap. If this were meant in the primitive way of a relation between sense data, then it would be impossible to defend any *law* of causality in the face of Berkeley's and Hume's criticism. If, however, thunder and lightning are regarded as physical disturbances and thus

as constructs, they stand indeed in a causal relation via the laws of physics. What significance, then, is to be ascribed to the statement: we live in a causal world? Only this: our experiences are such that they can be represented by constructs subject to the methodological requirement of causality.

It is often asserted that causality no longer holds in quantum theory. This, however, must not be taken too seriously. The facts are these In classical physics, the variables leading to causal description are, principally, the position and the momentum of a body. These fail to produce a causal representation for bodies on an atomic scale of magnitude. If, however, the state of the body is redefined in terms of other constructs the scheme becomes causal again. What worries many writers is that position and momentum still are not causally determined But this is hardly more surprising than the fact that Newton's laws are non-causal with respect to the color of the object they describe

(f) The list of metaphysical requirements would be incomplete without inclusion of one final item, *simplicity* This does not mean that constructs to be simple, must partake of immediately intuited properties designed for visualization: explanation need not be in terms of mechanical or any other kind of models But it does mean that the number of independently defined constructs appearing in any theory be held to a minimum Thus, for example, the electromagnetic theory of light is simpler than the elastic ether theory, although the latter is far more readily visualized than the former The fault of the ether hypothesis is that it becomes top-heavy with artificial assumptions when it is made to account for the speed of light and other matters It violates the requirement of simplicity.

This postulate is vague indeed. Its vagueness, however, does not impair its use; for it is invoked only when two rival theories compete for acceptance. When that happens there is usually some dissention among scientists, but history shows that it subsides and that the theory with the smaller number of independent constructs invariably prevails—provided, of course, that it is equally well confirmed

The requirement of confirmation has not been added to this list, for it is so basic in the scientist's methodology that it needs no special mention It inheres in the possibility of performing the circuit of explanation sketched in the foregoing section and is equivalent to it. A scientific construct, or a set of constructs joined into a theory, is said to be *valid* if, aside from being a link in confirmed circuits of explanation, it satisfies requirements outlined above.

The Physical Universe

But what, then, is the physical universe? To answer this question it is quite unnecessary to become involved in perplexing arguments concerning the external reality of things For this latter quality—if it be called a quality—we certainly do not observe it nor do we find a valid scientific construct which corresponds to it Let us look at the situation carefully. Why do we say that certain external objects are part of the physical universe whereas a seen ghost is not? The basis in individual sense data may be equally vivid, strong and convincing, hallucinations are known to be often more vivid than bona fide perceptions The reason for the distinction lies only in the fact that the external objects, as constructs, embed themselves in a peculiar nexus with other constructs, satisfying the metaphysical requirements for valid constructs in a simple, sometimes rudimentary way, whereas the apparition does not. Things are said to be objective, external to us, or independent of our minds, when they partake of the relatedness and internal organization

which confers validity on constructs. The atom, the electron form part of the physical universe in this sense, and in no other. But their "reality," if the term must be used, is therefore just as unquestionable as that of more familiar constructs.

Some will insist that sense data, also, belong to the physical universe. There is, I suppose, no harm in admitting them if only the dichotomy existing between them and the other elements is not overlooked. To wipe out the distinction, however, and to treat constructs as though they were sense data, leads to all the confusion and infelicity of expression, all the empty verbal argumentation which has often marred the philosophy of science.

According to this view, the physical universe is changing. It is a dynamic universe, one that is not being discovered as a static entity, but constructed as a thing of growing complexity and, we hope, perfection Understanding is a matter of approach to an ideal, not a grasping of a fact already there I believe that only this dynamic view conveys the perspective of modern science; the older realistic doctrine imprisons its spirit and obstructs its creative force.

If building a universe in which man's thought and actions play a dominant role is deemed anthropomorphic, then the present conception is anthropomorphic The alternative, a universe apart from man's thought and actions entrains the most embarrassing philosophical difficulties, and is without fertility in ethics and the social sciences. But here we are perhaps approaching issues which may be judged to be beyond the competence of present scientific methodology. Opponents of the exact sciences have spared none of their eloquence in disparaging the ephemeral nature of science. As an example, a most entertaining article by Stephen Leacock[4] may be cited. His criticism would not fail to be appreciated if the point of view of naive realism were still common among scientists; it would then be serious. As they stand, his arguments add further evidence to the constructional, dynamic interpretation of the universe. Even the old realistic world was conceded to change its properties in time Why should it not change its contents when new, valid theories are developed?

The foregoing discussion emphasizes the inseparability of fundamental theory from all scientific pursuits. The emphasis is perhaps untimely, since the practice in authoritarian countries, followed by a war-born shift of attitude even in the democracies, has added glamor to one-sided, practical scientific endeavors Let no humanist fear, however, that this is a permanent change. For all science would stagnate without the benefit of theoretical and philosophical stimulation

[4] Stephen Leacock, *Atlantic Monthly*, May, 1942.

SOME CTENOPHORE FISH-CATCHERS

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In a number of articles I have brought together all the facts and figures I could find relating to the fish-catching and fish-eating habits of the Coelenterate, or hollow-bodied, water-dwellers These animals, of which probably the best known are the fresh-water hydra and the marine jellyfishes, sea anemones and coral polyps (*not* "insects"), have a pronounced radial or starfish-like symmetry, the organs radiating out from a common center. Most, if not all, have the mouth surrounded by tentacles and both body and tentacles are abundantly supplied with poisonous nettle cells With the nettle cells fishes are paralyzed and with the tentacles are brought to the mouth, whence they are carried into the body cavity and there digested

The Ctenophores, or comb-bearers, as the figures show are transparent gelatinous water-dwellers, generally spherical or lobed, provided with a central cavity. They outwardly resemble the Coelenterates, with which they were formerly grouped. But they have only two tentacles instead of many and are entirely devoid of the poisonous stinging cells so characteristic of the Coelenterates. The tentacles are solid and each usually bears a row of short pinnae (Fig. 1). Both tentacles and pinnae are covered with cells called "colloblasts," or glue cells, which secrete little globules of gluey or adhesive matter. These cells with their secretion stick to any small objects which touch them, and hence with this secretion the Ctenophores catch their prey in very much the same fashion as the Coelenterates do with their stinging cells. The comb-bearers have the swimming organs arranged in four radially placed comb-like plates.

These characters and others not so apparent have led to the taking of these animals out of the coelenterate group and to the placing of them in a great zoological group or phylum of their own —the Ctenophora, or comb-bearers

And now, having cleared up these points, let us turn to the, to-us, more interesting and important matters of their food and feeding habits

The Ctenophores are not well known to the general run of zoologists and their food and feeding habits are almost unknown even to specialists in this group Thus the author of the section on these animals in Volume I of the "Cambridge Natural History" (1909) makes no reference whatever to their food and feeding habits. While an American authority merely says of the Ctenophores that, "Their food consists of crustaceans, fishes and other small animals, often including their own kind " However, Alfred G. Mayor, in his monograph on the Western North Atlantic Ctenophora, explicitly states that ". their food consists largely of young fishes which they engulf in great numbers, seizing their

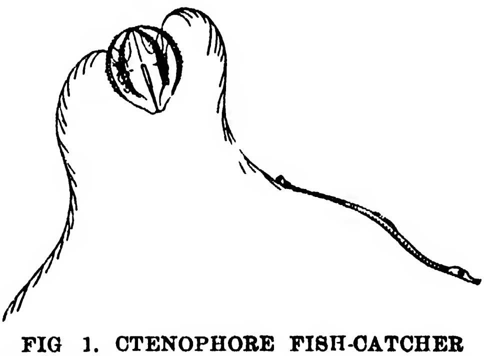


FIG 1. CTENOPHORE FISH-CATCHER
THE COMB-JELLY 10 MILLIMETERS LONG IN BODY, HAS LASSOED A 25-MILLIMETER BABY PIPEFISH.*

* Each of the figures is after Lebour.

prey by means of their peculiar "Greif-zellen' [pinnae]." Neither writer gives any references to help us along. It may be added that, when captured, Ctenophores are generally empty. However, this must be attributed to rapid digestion rather than to a starvation diet.

These small carnivorous marine animals must feed on the minute forms, the plankton, floating or swimming at the surface of the sea It seems impossible that they, being small, weak and apparently helpless, can catch and devour such relatively strong and active swimmers as even small fishes. Information along this line is desirable and fortunately is forthcoming.

Mertensia ovum, A FISH-EATER

When I wrote Dr. Henry B. Bigelow, Director of the Oceanographic Institute at Woods Hole, asking for information and references as to the fish-catching habits of the comb-bearers, he answered that the only one of which he had a record is that one bearing the formidable name above. It has no common name, unless we use the translation—Merten's egg-shaped comb-bearer. In 1780 this form was discovered by Fabricius and by him named Mertensia in honor of Professor F C. Mertens of Bremen, a marine botanist (if one may so designate a student of seaweeds). Nothing unusual seems to have been known about this comb-bearer until in 1909 when Dr. Bigelow,[1] on examining some specimens taken off the Labrador coast, found that one was a fish-eater

Of his specimen, Dr. Bigelow wrote that, "The voracity of this form is well illustrated by the fact that one individual [about 10 millimeters in height] had entirely engulfed a young sculpin no less than 21 millimeters long, the victim being doubled up so as to fit into the digestive cavity of its captor."

[1] Henry B. Bigelow. Coelenterates from Labrador and Newfoundland. *Proc. U. S. Nat. Mus.*, 37: 317, 1909.

Other than the above, all records come from Dr. Marie Lebour and from the Plymouth (England) Laboratory. In 1922, she made the first of her records and (so far as I have found) the second known personal record that Ctenophores catch and eat fishes. It seems well to quote her very words. In writing of the food of plankton organisms, she refers to that of one ctenophore kept under observation in an aquarium with a plunger for aeration of the water without changing it.

Pleurobrachia pileus, A FISH-CATCHER

This animal has no common name but a translation of its scientific name quite accurately describes it. *Pileus* means a cap, in allusion to the shape of the body of the animal, while *Pleurobrachia* apparently means having side branches, in allusion to the frilled chin strings of the cap, the tentacles with their many pinnae—as shown in the figure Of this animal, Dr. Lebour[2] writes (1922, p. 665) that. "In other years when records were not kept, Pleurobrachia was often seen to be eating young fishes, although only one is recorded here [with a young Labrus in it]." Her records published in 1923[3] are much fuller and hence of greater value:

> Pleurobrachia is known to eat young fishes amongst the large variety of food which it takes Several ranging, from 3 to 10 mm long, were kept alive in the plunger jars from June to August, 1922.
>
> These ate . . . [among other organisms] pipefishes (Syngnathus, about 25 mm. or one inch long) In one case a Pleurobrachia, about 10 mm. long [body only] caught a pipefish, about 25 mm. long (Fig. 1). After playing with it for half an hour the fish escaped, carrying most of the tentacle with it The heads of the pipefishes eaten are usually ejected A Pleurobrachia about 4 mm. long caught and partly digested a goby over 10 mm. long, which it could not get entirely into its mouth.

[2] Marie Lebour. The food of plankton organisms. *Jour. Marine Biol. Assoc., U. K.*, Plymouth, 12 664–7, 1922.

[3] Marie Lebour The food of plankton organisms. II. *Jour Marine Biol. Assoc. U. K.*, 13: 85–87, 1923.

When strong and well the Pleurobrachia has its tentacles with their pinnae fully outstretched and catches the food as it passes by, immediate reaction taking place at the touch of the prey, which is [held by the glue cells] entangled in the contracted tentacle and conveyed to the mouth and stomach.

Dr Lebour examined tow-net material collected in the eastern part of the English Channel in January, 1923. Pleurobrachias in it were very large—about 18 millimeters in diameter. Nearly all of these had eaten fish eggs or young fishes, some of them having the mouth and stomach "enormously extended, the aperture being nearly half the diameter of the body," as is shown in the subjoined Fig 2 Here follow some detailed counts, segregated in lots according as the material came in

Of large Pleurobrachias (18–20 millimeters in diameter), Lot I contained eggs and young fishes as follows—two contained one herring each; one, two herring; and one several herring; and three had swallowed plaice eggs Of Lot II, three contained one herring each; one, had two; four had three; two had four; one had five; three were crammed with six herring each; and one with two larval plaice (much larger than the herring). Of Lot III, one contained several larval herring and three had eaten plaice eggs Of Lot IV, Dr Lebour notes "Many Pleurobrachia containing herring larvae." Tow-net records for June, July and August, show various young fishes in smaller numbers contained in specimens of this Ctenophore

Now follows Dr Lebour's[4] interesting account (1925) of her observations of fish-catching by the Ctenophore lacking the long tentacles so skillfully used by Pleurobrachia.

Bolina infundibulum Catches and Eats Young Anglers

The dictionary tells us that Bolina is a made-up New Latin word but gives us

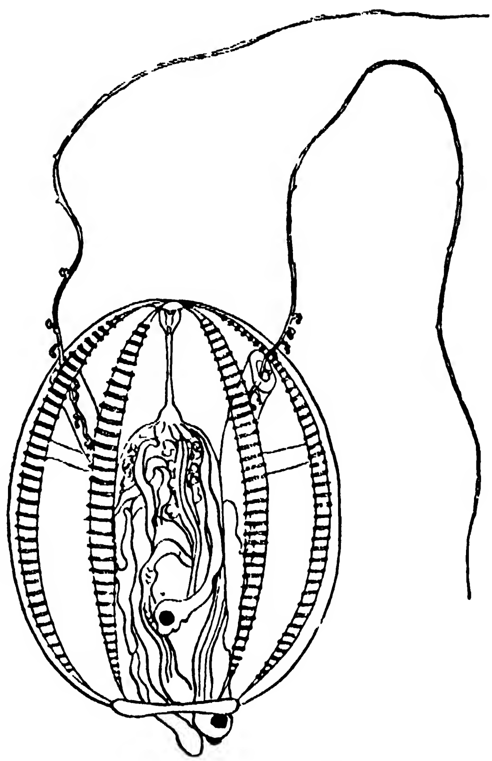


FIG. 2. A CTENOPHORE FILLED WITH YOUNG HERRING. THIS SPECIES FEEDS EXTENSIVELY ON LARVAL HERRING.

no derivation Infundibulum refers to the funnel-shaped mouth Hence this Ctenophore is Bolina with the funnel-shaped mouth—into which it takes little fishes. And here is how it does it.

These lobate ctenophores appeared suddenly in the jar early in the spring, having apparently been introduced as eggs when very fine plankton was put in They had been feeding freely on copepods and it was thought that the Anglers would be safe beside them This was, however, not the case, for the Bolina caught and ate many of the little fishes The method adopted was interesting. The ctenophore would catch an actively moving fish with its tentacles, which although short are very powerful, and as the fish struggled the lobes would close on it, shutting it in, when it was quickly taken by the mouth, from there it reached the stomach and was digested [Fig. 5 a–d; my Fig. 3 a–d]. Bolina from 4 mm. to 30 mm. long would catch fishes in this way, the smallest taking one longer than itself, the largest sometimes taking two at a time or eating one after another. Bolina is thus seen to be extremely voracious and evidently able to

[4] Marie Lebour Young Anglers in Captivity and some of their Enemies. *Jour. Marine Biol. Assoc V. K.*, 13: 728, 1925.

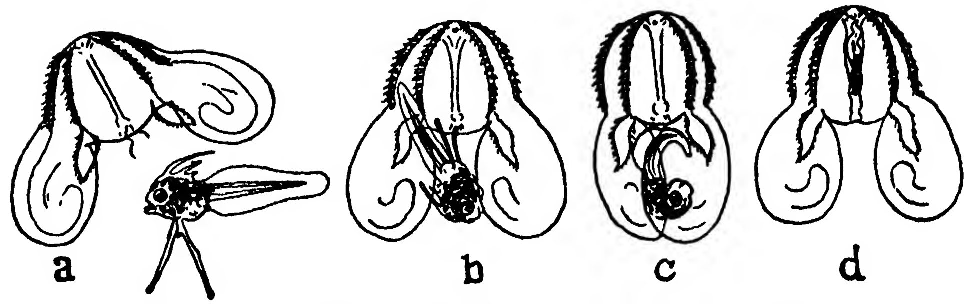


FIG. 3 THE COMB-BEARER CAPTURES A YOUNG ANGLER
(*a*) THE LITTE ANGLER WALKS INTO DANGER; (*b*) HE IS BEING FIRMLY GRASPED BY THE TENTACLES; (*c*) INGESTION IS GOING ON; (*d*) MAY BE LABELLED "DIGESTED"

tackle larger food than any previous knowledge of its feeding habits has hitherto shown. Altogether it accounted for the death of many of the Anglers, which would quickly run out of the way and hence required a good deal of catching. Those of all ages, from newly hatched specimens to those of the tenth day, were taken and always from near the surface or center of the jar never at the bottom.

By now the reader is asking, "Can these animals, which are so small and helpless, do so much damage to a crop of young fishes as to justify their being designated as their 'enemies'?" On this point we have the following general statement from Mayor[5] (1912). "In cold northern waters, where Ctenophores occur in vast swarms, they constitute a serious menace to the cod fisheries by devouring the pelagic eggs and young fish." Then when one reads in Dr Lebour's scanty records that nine had eaten fish eggs; that several contained three, four and five fishes each, and that three had gorged themselves with six herring each; that several had swallowed fishes larger than themselves; and that in all 21 Ctenophores contained a total of 66 baby fishes—one must surely consider them as "enemies" This is confirmed when one learns that Ctenophores go about in great shoals, sometimes acres in extent—all seeking food, young fishes among other things.

To recapitulate: The few samples taken at random from tow-nettings show that these hungry little animals have captured considerable numbers of baby fishes. Multiply these few individuals by the countless numbers contained in an acre-sized shoal. Then from this astronomical number one can get an idea of the heavy toll of young fishes taken by these voracious Ctenophores. Surely they are to be set down as "Enemies of Fishes."

[5] Alfred G. Mayor. The Ctenophores of the Atlantic Coast of North America. Carnegie Institution of Washington. (Ctenophores feeding on fishes, pp 6 and 7)

AN AMERICAN PIONEER IN SCIENCE, DR. WILLIAM CHARLES WELLS, 1757–1817

By Dr. CHARLES A. KOFOID

PROFESSOR EMERITUS OF ZOOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY

In reality the only claim America has upon the fame of Dr. William Charles Wells (1757–1817), a pioneer in physics, meteorology, ophthalmology, epidemiology, and anticipator of Darwin, is his birth at Charlestown, South Carolina He never forgot his Scottish ancestry and this allegiance was reinforced by his education at the Grammar School at Dumfries, and his medical degree from Edinburgh. Furthermore his whole intellectual life was later centered in the Royal Society of London.

He never mentions his native land, never sought the acquaintance of Benjamin Franklin, and his recollections of Charlestown were embittered by memories of court-martials of fellow citizens in the political turmoil of the rising tide of the Revolution. As a refugee loyalist at the close of the War of Independence he had sought asylum in Florida where, with the aid of a "Printer's Grammar" and a negro slave, he set up and printed the first newspaper published in that state. His brief career in Charlestown as a printer, publisher, and merchant culminated in the settlement of the family estate which left him saddled with a debt of honor of £600 which it took him many years to pay off. His lingering bitterness against his American background emerges in his anonymous tirade in the *London Advertiser* against the fitness of Henry Laurens, chairman of the Constitutional Convention, to represent the American Republic at the Court of St. James.

There was, however, one bright spot in this dismal background. It was the friendship of Dr. Alexander Garden of Charlestown, his guide and counsellor in youth and his medical preceptor. Dr. Garden was the leading scientist of the Carolinas, a correspondent and member of the Royal Society, and a botanist of note whose name is enshrined in the fragrant *Gardenia* In the atmosphere of this friendship Wells' scientific and medical interests found a congenial environment and he records his appreciation of its lasting influence upon his career

It was this American environment, however, which gave Wells an insight into the contrasts between the white and negro races and revealed to his analytical mind their differential survival to the decimating diseases of consumption and ague, a contrast which was of assistance to him in formulating his theory of natural selection.

Like many American youths of his day he went to the University of Edinburgh where he attended medical lectures, passed the examinations, but wrote his thesis in Leyden in 1779 on *De Frigore,* a forecast of his lifelong interest in the formation of dew. After attendance at St. Bartholomew's Hospital in London he returned to Edinburgh for his degree in 1780.

Scientific ideas vary greatly in their significance. Some concern only a minor supporting factor in a larger edifice, such as the meaning of vestigial organs seen in the gill slits in the neck of the mammalian embryo but never directly used in respiration. Others form the foundation of a growing and changing superstructure whence radiate influences which stimulate new points of view in widely different fields of human thought and activity. Such an idea is

that of the origin of species by natural selection, often called Darwinism, or less accurately evolution, or to limit it to the living world, organic evolution.

Charles Darwin, however, did not use the word evolution in his "Origin of Species," but his masterpiece attracted world-wide attention to the process to which the writings of Herbert Spencer and Thomas H. Huxley later attached the word evolution and thus gave to it a lasting place in popular parlance.

Wherever some seemingly new idea is broached, given popularity, and comes to be associated with the proposer's name, critics appear who find that the theme after all is not so new, that others have expressed the same bright idea. They thus proceed to rub off the sheen from the supposedly pristine contribution Exactly this happened to Charles Darwin's concept (1859) of the origin of species by natural selection. By the time the fourth edition (1866) of his masterpiece appeared his expanding correspondence had brought to him evidence that he had been explicitly anticipated by at least two naturalists of British affiliation. He generously gave credit to his anticipators in his historical introduction to that edition These anticipators were Matthews in his "Naval Timber" and Dr W. C Wells in his "Account of a White Female part of whose skin resembles that of a Negro "

One would hardly expect the outline of a major biological theory in a dry and technical treatise urging an adequate and continuous supply of building material for the bulwarks of the "Royal Oaks" of Britain's navy. Yet here it is in Matthews work interlarded in a plea for more oaks, not of the ordinary quality but of an increasingly better one This is to be accomplished by a survey of all of the known varieties of oaks, the selection of the finest and their interbreeding, the planting of acorns from these paragons which would supposedly transmit to their progeny the qualities selected. Then in due time the British forests of oak would be transformed into groves of new and better oaks.

The second anticipator of this discovery of change in the hereditary patterns of living things by natural selection both deserved and received Darwin's fullest recognition. He cites Wells' paper on "An Account of a White Female part of whose skin resembles that of a Negro" read before the Royal Society of London in 1813 but not published till 1818 after the author's death He acknowledges that in this paper Wells distinctly recognizes the principle of natural selection and that this was the first published statement of that principle, but states that Wells applied it only to the races of men and to certain characters alone. In these restrictions Darwin overlooked the fact that Wells noted that "amongst men as well as among animals varieties of a greater or less magnitude are constantly occurring" and that he also specifically cited selection constantly occurring in sheep Wells also compared natural selection in human characteristics with man's artificial selection among variations of his domesticated animals, noted the survival value of the variations on which selection acted, the swamping out of these characters by interbreeding, the non-inheritance of some characters (since he knew nothing of Mendelism and recessive characters) and the effect of isolation in conserving the characters selected By a clean-cut process of ratiocination he resolves this instance of a pinto female into a full-blown theory of variation, selection, descent with modification, and the origin of new races of men. He draws upon his knowledge of the reaction of human races to disease as an instance of the operation of selection. It is of interest on this point to recall that although Darwin had studied medicine at Edinburgh he never mentions disease as a selective agency in his "Origin of Species" and only casually notes it in his "Descent

of Man." Wells, on the other hand, utilizes it as a potent agency in the evolutionary process.

The wish to learn more of the character and other writings of this anticipator of Darwin led me in a month of leisure in November 1936 to consult the great library of the British Museum and the manuscripts of the Royal Society In the nearby library of the College of Physicians and Surgeons was found his contributions to the little known "Transactions of a Society for the Improvement of Medicine and Chirurgy," all but stillborn before its time, which bear further witness to the intellectual keenness of Wells' mind. Before the days of Pasteur he maintained that erysipelas was contagious and long before the word epidemiology was coined he pioneered therein with a discussion of the seeming opposition in occurrence between consumption and ague.

It was not, however, in his chosen profession that Wells exhibited his prowess, for he seems to have been but a mediocre practitioner, barely eking out a meager living in spite of his affiliation with one of the greatest of London's hospitals He was, however, constructively interested in the standing of his profession as shown by his fight for the rights of graduates of Scottish Universities as against the entrenched privileges of those of Oxford and Cambridge who then constituted the membership of the College of Physicians and Surgeons A court decision had equalized these but the privileged group had as yet made no move to put the liberal policy in action When later the College of Physicians and Surgeons offered membership to him he declined it because of this illiberal policy.

His scientific fame rests on three contributions in widely separated fields, namely his anticipation of the evolutionary doctrine of natural selection, his penetrating discussion of the perennial problem of single vision with two eyes, and the logical explanation of the recurrent commonplace of the deposition of dew on clear nights.

The first of these touches upon a theme of greatest importance, namely, the factors in organic evolution It also anticipates in its statement of the argument, Darwin's own presentation of the origin of species by natural selection This, however, was the least elaborated of the three major contributions and remained unpublished until after his death and practically unnoticed thereafter, until Darwin gave it posthumous fame in the historical introduction to the fourth edition of the "Origin of Species" At most Wells' reference to the selective process is only a casual comment on an interesting abnormality occasioned by his contact with a case of a White Pinto, that is, a person with contrasted regions of white and black skin This led to his disquisition on the causes of differences in color and form between the white and negro races of men. This paper was presented by Wells before the Royal Society of London on the first and eighth of April, 1813 In the manuscript book of minutes of the Royal Society the secretary gives an excellent résumé of the paper, possibly furnished by Wells, but no comment appears in the record for this division between two sessions or of any discussion aroused by its reading The paper was published after his death but excited no comment or criticism at that time or later

The manuscript of this paper was found upon search among the uncatalogued papers of the Royal Society by whose courtesy a photostat was made of it. A comparison of this with Wells' signature in the records of the Royal Society supports the conjecture that the manuscript is in Wells' own handwriting. A comparison of this manuscript with the text of the article in his collected works, edited presumably by Dr. Patrick, reveals no evidence of modifica-

tion due to contemporary discussion or general criticism. It was only after the doctrine of Special Creation had been challenged that Wells' ideas acquired significance.

A search for evidences that he had been directly influenced by contemporary French thought on evolution was fruitless, there being no suggestion that he had made contacts with either Buffon or Lamarck or that he even knew of their writings. A possible indirect relation exists through his friend David Hume, who visited France and writes of his pleasure in his conversations with the brilliant Buffon. All of this goes to show that Wells himself was unaware in his time of the far-reaching turmoil of thought which would one day be set in motion by his casual ideas on natural selection, under the impetus of Charles Darwin.

Wells' fame rests, however, not so much upon his anticipations of Darwin as upon his "Essay on Dew." His interest in temperature and the far-reaching effects of its changes upon nature and man was further stimulated by one of his patients, a retired merchant from India, who told him of the commercial production of ice in Calcutta by the primitive method of exposing water on clear nights in shallow pans of porous earthenware on wet straw in the unshaded moonlight. The rapid radiation of heat from the pan and the straw, under these conditions, sufficed to form ice in the pan. Wells was wont to leave the perpetual haze of London and to experiment on the formation of dew in the garden of his merchant friend in the moonlit suburbs. These experiments led in time to his "Essay on Dew" which won for him the Rumford gold and silver medals and membership in the Royal Society of London, than which there is no higher scientific honor.

Many other physicists and meteorologists had anticipated Wells in experimental analyses of various factors in the formation of dew, but it remained for him on the basis of his own experiments to determine and to formulate a complete theory. So complete and so logical was this presentation that John Stuart Mill in his "System of Logic" quotes this essay as a perfect example of logical induction. He concludes that "The accumulated proof of which the 'Theory of Dew' has been found susceptible is a striking instance of the fullness of assurance which the inductive evidence of laws of causation may attain, in cases in which the invariable sequence is by no means obvious to the superficial view." Herschel selects Wells' theory of dew as "one of the most beautiful specimens we can call to mind of inductive experimental enquiry lying within a moderate compass."

Science advances step by step of verifiable discoveries of basic truths and by the incorporation of these in hypotheses the reliability of which can be tested by experiment. The inductive method of scientific discovery which Lord Bacon advocated but never used was logically and expertly applied by Wells. His work is a milestone in the history of science. He had one of those rare analytical minds which discover and formulate from the temporary and commonplace the abiding and universal laws of nature.

BOOKS ON SCIENCE

CIVILIZATION AND TEETH[1]

"YOUR Teeth Their Past, Present and Probable Future" is a perfect résumé of dental history and is the only book I have read, scientific or otherwise, with which I agree in every respect From the number of references cited, it must have taken extensive reading and study, as well as time, to abstract and compile all the data accumulated It is a book which should be read not only by every dentist, but by every dental student as well, for the facts presented will help the student at the beginning of his dental career from being misled by the "cure-alls" for dental troubles which are flooding the dental offices to-day However, I doubt if many lay readers will continue beyond the first or second chapters, as few people to-day are interested in preventive dentistry or medicine I make this observation from my own practice, where the large majority of my patients refuse to listen or to do those things which will prevent additional cavities While this book is one of facts, it does not give the dental profession the answer to the question, "What can I do to preserve beautiful teeth?," and I am still in a quandary as to what I should do with my patients to prevent dental decay

There is no doubt that civilization is the cause of dental diseases The process of chewing is a lost art, for most of our chewing has been done at Battle Creek, Michigan, and other centers where prepared foods are made At the table, the little child of three or four is told to keep his lips shut and not make any noise in the process of eating, which is a physical impossibility with real chewing And after eating this mush and paste that foods have become, this little child must not take his tongue and clean the gums and tissues to rid the mouth immediately of large food particles Instead, the debris is allowed to remain there, for it is not nice and not good manners to hear the noises of saliva going around and between the teeth Thus, the interproximal spaces and gingival margins are crammed with this food material, until such time as the child is old enough to use a toothbrush And, then, what is the child given? A brush which is stiff enough to take the surface from any furniture, with which he is taught to scrub the buccal and labial surfaces of the teeth with some kind of tooth powder or paste, doing absolutely nothing for the interproximal spaces, where most of the trouble begins It is true that a clean tooth never decays, and to clean the buccal and labial surfaces of the teeth, which usually never decay anyway, is about all that is accomplished by the average person

The result of this modern culture is that the chemistry and bacteriology of the retained foods cause the teeth to disintegrate, with the resultant pyorrhea and abscesses, which have impaired the health of many individuals This is described fully in the second and third chapters

By reason of modern foods, loss of teeth and impaired function from generation to generation, we come down to the present day of dental deformities and the lack of physical development of the individual in a large number of cases, when we study and compare the teeth of those peoples who live primitively and the transition in animals from their native land to the domestic home These data are clearly proved by the facts presented in chapters seven and eight.

[1] *Your Teeth Their Past, Present and Probable Future* Peter J Brekhus Illustrated xvii + 255 pp $2 50 1941 The University of Minnesota Press.

The wonderful strides made in dentistry have not kept pace with the crying need for more dentists, and I believe it is an impossibility at the present time to have sufficient dentistry in every town and village to care for all the children and adults who need attention All the congresses, surveys and recommendations to state and federal agencies will help, but they will never correct or prevent the most widespread disease of civilization, dental caries It is true that we have investigators searching for the cause of our tooth troubles with the aid of the microscope, modern chemistry and biochemistry, but I agree with the author that the end results of these investigations will get us nowhere until we change our mode of living, going back to the "good old days," which are gone, never to return Just about the time, in generations to come, that a "cure-all" for dental ills will have been discovered, the human race will probably be devoid of teeth, and then, of course, the "cure-all" will be unnecessary

One subject on which the author has not touched is the clear evidence that under normal conditions the use of the toothbrush is not indicated and that people should not need to clean their teeth The clear mucine which covers the teeth at all times is the protective coating against acids taken into the mouth in the form of foods, such as the acid of lemon. The enamel of a tooth, perfectly clean and free of mucine, immersed in lemon juice will be etched much the same as hydrofluoric acid will etch glass, and if the mucine of modern man could be changed to the qualities of primitive mucine, it would not collect these liquid foods and hold them against the teeth with the consequent decay With me, today the question is, "Which does the greater damage, 'depraved saliva' or scrubbing with a toothbrush?" I recommend to my patients the use of the softest toothbrush available, so that they will be able to mash the brush between the interproximal spaces without injuring the gums, to remove this film of mucine with its contained food particles In a very few cases, this "depraved saliva" or film has been changed by diet to one which will not collect these food particles Not a complicated diet, but just natural foods No artificial sugar, but the natural sugars of ripe fruits, no white flour; no pies, cakes, nor candy, just natural foods—fruits, vegetables, meat, milk, eggs, butter, etc, properly cooked.

The past is prologue, the present is calamity, and the future will take care of itself

R K Thompson

A PHILOSOPHY OF EDUCATION[1]

The idea underlying this volume in the philosophy of education is a very excellent one Indeed it is unique among books in this field Even though the execution of the book does not quite live up to the excellence of its conception, its unique approach to the philosophy of education amply justifies its publication and recommends its reading and study

The way in which the book is conceived and organized is very reminiscent of the role President Hutchins assigned to philosophy in his lectures published as "The Higher Learning in America" There he calls attention to a certain atomism in our education He finds that students study a great variety of discrete courses, but nowhere is provision made for bringing them into any integrated relation to each other. This should be the role of philosophy Philosophy should not be only one more atom in the curriculum; on the contrary, it should be even more an integrating matrix for them all Indeed, it should be the very queen of the arts and sciences

President Hutchins' critics have borne down so heavily upon *his particular*

[1] *An American Philosophy of Education* J. C. Knode, editor. viii + 553 pp. $3.25. 1942. D Van Nostrand and Company.

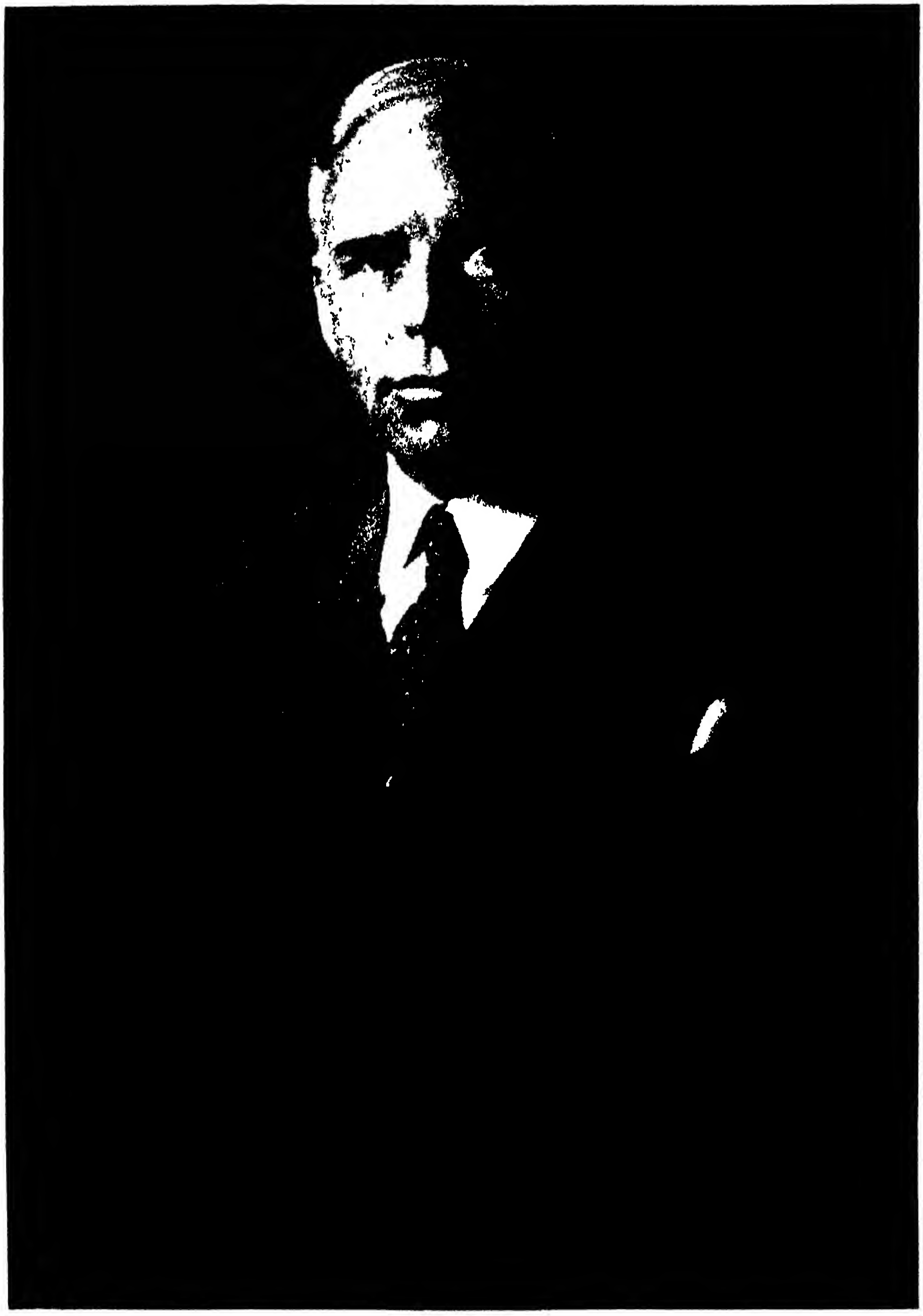
philosophy that the importance he has attached to the unique role of any philosophy has been unfortunately much neglected This function of philosophy, far from being overlooked in the volume under consideration, is the very principle of its organization To the editor and his collaborators it appears that a satisfactory philosophy of education is not an isolated nor narrow set of educational theories concerning the methods and curricula of the school Rather is it a point of view which draws its strength from an intimate acquaintance with the broad field of culture

In the opening chapters of the book the young teacher's attention is first directed to the background materials in science, history, philosophy, literature and fine arts which he will need as a basis for his philosophy of education The editor's collaborators have contributed chapters in these fields which are admirable for the way in which they have mobilized the most important items in the economy of space allotted The editor himself has contributed the philosophical background But most significant he has written the all-important chapter, ' Toward Synthesis ''

As already said, this is an excellent pattern for a book on the philosophy of education But it has limitations—of execution if not of design In the first place it lacks chapters on parts of the cultural background which are eminently necessary, such as chapters on politics and economics This is not to say that these topics are altogether slighted, but they are not given coordinate status, as they should be, with such chapters as those on biology, psychology and sociology In the second place the book seems to have overdone its chief merit; it appears to be overweighted in the direction of cultural backgrounds for a philosophy of education There is such an emphasis on cultural point of view that anxiety may seriously be entertained whether the "young teacher," to whom the introduction is addressed, will readily see its application or significance for the practical every-day concerns of method, curriculum and administrataion Perhaps this is the area to which classroom instruction is to address itself In other words, in the last place, there is a larger job of "synthesis" to be done than just one chapter allows for The editor has striven valiantly to bring the materials of a dozen or more chapters into focus but the materials with which he was wrestling were so vast that he might well have allowed himself at least two or three more chapters in which to complete his task

The very least that can be said for the book is that it is a definite and worthy contribution to the teaching of philosophy of education at its weakest point in this country, the cultural background of the prospective teacher It is a cultural orientataion and summary for him if nothing else As such it should be at least a companion or supplementary volume for almost any course in the philosophy of education that one could mention At best, particularly with good teaching, the book can aspire to the regal role prescribed by President Hutchins for philosophy.

JOHN S BRUBACHER



DR. ARTHUR B. LAMB

THE PROGRESS OF SCIENCE

DR. ARTHUR B. LAMB, RECIPIENT OF THE WILLIAM H. NICHOLS MEDAL[1]

IN an age of specialization which is constantly becoming deeper and narrower especially in the sciences, Arthur Becket Lamb is an inspiring exception He stands as solid proof that broad training and experience are not incompatible with the highest success in a narrower field His achievement of the latter was evidenced by an award of a "star" in the third edition of "American Men of Science." Entering high school at the age of twelve in Attleboro, Massachusetts, he took the college preparatory course which included Latin, Greek, French, algebra, geometry and history He had early shown a talent in drawing and so spent his Saturdays taking drawing lessons and also lessons in German Through the Superintendent of Schools, who was an enthusiastic amateur astronomer, Lamb and some of his chums followed the same fascinating route The little group specialized in double stars and tried to spot all which could be resolved by their eight-inch instrument When the parents of the little group rebelled against the midnight and early morning hours, Lamb's interest turned to microscopes He finally bought the more difficult parts from Bausch and Lomb and constructed a microscope of his own in the tool-room of his father's jewelry factory. The making of the microscope showed him a lot about tools and metal-working techniques, and its use opened his eyes to the multifarious and beautiful life in the streams and ponds of the countryside During his high school years Lamb's keenest formal interest was in mathematics He was one of those rare individuals who does mathematical problems for the fun of it He even dabbled in constructions for trisecting an angle and for laying out a regular pentagon. Although he took no regular science course in high school, he spent some spare time with the introductory portions of the four volumes by Roscoe and Schorlemmer, the only chemistry work in the school library He also worked a little in the physics laboratory after hours On being quizzed on his science activities in high school, Lamb admits that the only experiment he remembers is the measurement of the surface tension of water by the drop-weight method, but he can not recall what led him to carry out this unusual experiment His senior year corresponded with Roentgen's discovery of x-rays He and his friends combined a small Crookes' tube and a frictional electric generator and were able to take a shadow picture of a key placed against a box containing a protected photographic plate

At sixteen, Lamb entered Tufts College and quickly became interested in biology probably because of his knowledge of the microscope and his skill at drawing He stayed with biology through his Bachelor and Master's degrees His thesis for the latter was on the eye muscles of the common dog fish (*Squalus acanthias*). This was his first published article During his college years, he continued his interest in mathematics, going through quaternions and the Newtonian Potential Theorem. He

[1] Awarded by the New York Section of the American Chemical Society, to the author or authors of the best paper "on the science or practice of chemistry" Investigators are eligible who have published original contributions in any of the publications of the American Chemical Society, or those under its auspices, during the three years preceding the presentation meeting.

THE WILLIAM H NICHOLS MEDAL

also took practically all of the courses in chemistry which were offered He finally decided to move into that field During his senior year he had started work with Arthur Michael on a small research problem in inorganic chemistry on iodine oxides He soon changed to Michael's major interest, organic chemistry, and studied the isomerism of the coumaric acid. While Michael was away for a year Lamb continued his research and taught two of his advanced courses As a side line he was continuing his interest in biology and published a short paper on the "Mechanics of Mitosis" He also spent a summer at the Marine Biological Station at Harpswell and succeeded in repeating with the sand dollar the brilliant experiment of Jacques Loeb on parthogenetic development

After receiving the Master's degree Lamb decided definitely to go into chemistry, and into physical chemistry at that Meanwhile he continued his work in organic chemistry Although he had originally planned to go to Johns Hopkins University his decision was changed by his meeting Theodore William Richardson He went to Cambridge and concentrated on physical chemistry.

Before transferring to Harvard, Lamb had completed all of the work for his Ph D in organic chemistry at Tufts under Arthur Michael, except for taking the final oral examination He finally took in the same year the Ph D in organic chemistry from Tufts and the Ph D in physical chemistry from Harvard, a unique demonstration of versatility The combination with a Master's degree in zoology makes the achievement even more remarkable

Lamb then went to Europe for a brief period to study in Leipzig, Heidelberg and Goettingen He then returned to Harvard for a year as instructor and then went to New York University, where he stayed until 1912 and became Director of the Laboratories The latter year he returned to Harvard, where he has stayed continuously except for the period of the first World War which he spent in Washington

Early in 1917 Lamb undertook some work for the Military Intelligence Department in Washington on secret writing He soon took up work on the removal of carbon monoxide from air This work was done in collaboration with the late Charles R Hoover, of Wesleyan University, who lost his life in the present World War They eventually developed a detector for carbon monoxide which they named "Hoolamite" It is interesting that it contained iodine pentoxide, one of the substances on which Lamb had worked as an undergraduate with Michael Late in 1917 Lamb took leave-of-absence from Harvard and became head of the Defense Section of what was to become the Chemical Warfare Service Research Unit at the American University in Washington He was commissioned a Lieutenant Colonel in the C W S A large and effective organization was soon built up One of the most important achievements of the group was the development of the catalyst for the conversion of carbon monoxide in a gas mask into harmless carbon dioxide. This was carried out by workers from Johns Hopkins University and the University of California The catalyst was finally called "Hopcalite" in honor of the two universities

After the Armistice, Lamb went through a serious period of decision as to his future activities At one time it seemed that he should continue as head of the Research Division of the Chemical Warfare Service He also received tempting offers to head research organizations for some of the largest corporations in the country He finally decided, however, to return to Harvard Before doing so he served briefly as director of the Fixed Nitrogen Laboratory in Washington during the important period of its organization

While Lamb's list of scientific publications is an imposing one and is characterized by unusual diversity, his greatest achievement in science will undoubtedly stand as his editorship of the *Journal of The American Chemical Society* which he has held since 1917 Under his charge this has become the greatest chemical journal in the world

In 1940 Lamb was appointed dean of the Graduate School of Arts and Sciences of Harvard University

Along with his busy life he has found time to serve as a valued consultant to many large chemical industries and has achieved an outstanding position as a chemical expert in many important patent litigations He has received practically all of the honors and recognitions which can come to an American chemist, including membership in the National Academy of Sciences and the presidency of the American Chemical Society.

On the human side, Lamb is one of the most robust and virile of men and yet withal as kindly and friendly an individual as one can ever hope to know

F C Whitmore

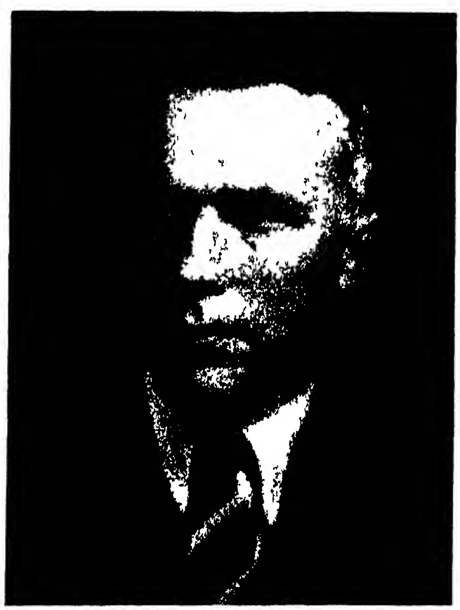
MEDALISTS OF THE NATIONAL ACADEMY OF SCIENCES

At its eightieth annual meeting the National Academy of Sciences awarded five medals to workers for extraordinary contributions to progress in certain fields of science This custom of bestowing a medal upon an individual as a tangible recognition of an important accomplishment is an old one; originating with the armed forces in ancient times to commemorate acts of valor, it has gradually been adopted by national organizations to honor individuals for high achievements in various branches of human endeavor Within each organization special trust funds have been set aside to encourage activity in special fields. Each trust fund is administered by a special committee charged with the responsibility of recommending to the organization candidates for the honor. Upon formal action by the organization the medal is awarded and then bestowed at an appropriate time

The National Academy of Sciences follows this procedure and bestows medals on the occasion of the annual dinner, at which the president ordinarily speaks on the status of the Academy and on the aid it has rendered to the government in problems on which advice has been asked Under present war time conditions the major part of the activity of the Academy is restricted to government problems, upon which general reports are made at closed sessions of the Academy, thus relieving the president of the need for the usual statement of progress

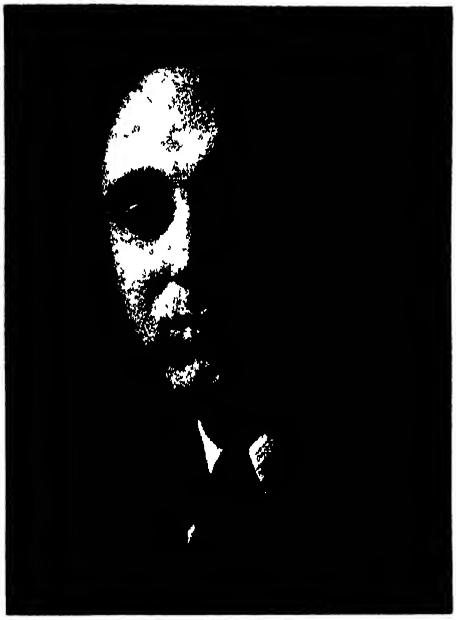
At the annual dinner this year attendance was limited because of catering difficulties, to Academy members and medalists President Jewett in his opening remarks described briefly the five medal awards and the trust funds from which they were derived The medals were then bestowed in the order of estab-

DR IRA SPRAGUE BOWEN
PROFESSOR OF PHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY.



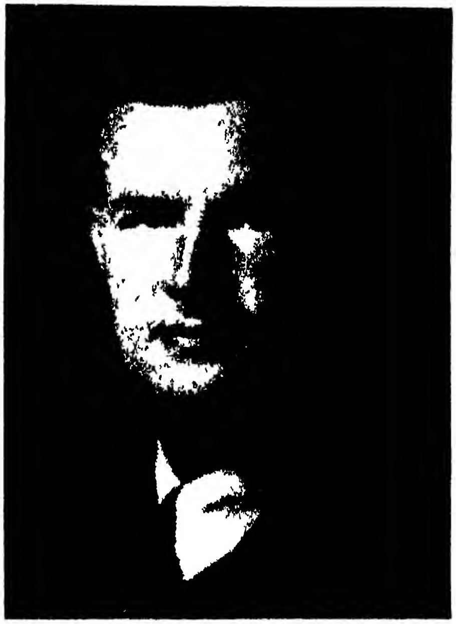
Harris & Ewing

COLUMBUS O'DONNELL ISELIN, II
DIRECTOR OF THE WOODS HOLE OCEANOGRAPHIC INSTITUTION



Bachrach

DR. EDWIN H COLBERT
DEPARTMENT OF GEOLOGY AND PALEONTOLOGY, AMERICAN MUSEUM OF NATURAL HISTORY



Blackstone

DR ROBERT CUSHMAN MURPHY
CURATOR OF OCEANIC BIRDS, AMERICAN MUSEUM OF NATURAL HISTORY.

lishment of the trust funds In each case the president called upon the chairman or representative of the committee which made the recommendation to present the candidate and to state briefly the reasons for the selection

The Henry Draper Gold Medal

The Henry Draper Medal was awarded to Dr Ira Sprague Bowen, professor of physics, California Institute of Technology, "in recognition of his contributions to astronomical physics, more especially his researches on the spectra and chemical composition of the gaseous nebulae " The presentation speech was written by Dr J H Moore, of Lick Observatory, chairman of the committee on the Henry Draper fund; in the absence of Dr. Moore, it was read by Dr. S. A Mitchell To quote the first paragraph of this speech:

More than three-quarters of a century ago, Huggins, a former Draper medalist, found that the spectra of certain nebulae were composed of sharp isolated bright lines, thus proving that their luminous material is a glowing rarefied gas Some of the lines were recognized as those of hydrogen, and, later, others were identified as due to helium and ionized carbon, oxygen, and nitrogen, but nearly half of the nebular radiations, including the two strong green lines, could not be matched in any terrestrial source. These mysterious radiations were believed to indicate the presence in the gaseous nebulae of an unknown element "nebulium" and for more than sixty years the nature of "nebulium" remained one of the outstanding problems of physical astronomy with which the ablest spectroscopists had struggled and had failed. It was solved not by an astronomer but by a physicist, Professor Ira Sprague Bowen, of the California Institute of Technology.

The Alexander Agassiz Gold Medal

The Agassiz Medal with honorarium was bestowed upon Columbus O'Donnell Iselin, II, Director, Woods Hole Oceanographic Institution, "for his studies of the Gulf Stream system, for his leadership in the development of a general

program of the physical oceanography of the North Atlantic, and for his distinguished direction of the activities of the Woods Hole Oceanographic Institution, both in peace and in time of war" The presentation speech was made by Dr Thomas Barbour, member of the Murray Fund Committee which recommended the medalist In his talk Dr Barbour recalled incidents in the life of Alexander Agassiz after whom the medal was named by Sir John Murray, donor

Bachrach

DR EDWIN G CONKLIN
DEPARTMENT OF ZOOLOGY, PRINCETON UNIVERSITY.

of the Murray Fund In the words of Dr Barbour, "I wish to put on record the fact that I can think of no one who could stand as recipient and be more utterly satisfactory to Mr. Agassiz as him whom we honor now."

The Daniel Giraud Elliot Medal

The Daniel Giraud Elliot Medal for the year 1935 was bestowed upon Dr. Edwin H Colbert, of the American Museum of Natural History, in recognition of the high merits of his work "Siwalik Mammals in the American Museum of Natural History," published in the Transactions of the American Philosophical Society in 1935 The medalist was presented by Dr Wm K Gregory, a member of the Daniel Giraud Elliot Fund Committee Dr Gregory emphasized the importance of the work of Dr Colbert on the fossil mammals of India; in this field much work has been done during the past century Dr. Gregory stated that in Dr Colbert's "detailed analysis on the migration of certain mammals to and from the Siwaliks, we see India as at the crossroads, exchanging mammals with Europe and Africa on the one hand, and with Asia and North America on the other"

The Daniel Giraud Elliot Medal for the Year 1936

The Daniel Giraud Elliot Medal of 1936, with accompanying honorarium of $200, was given to Dr Robert Cushman Murphy of the American Museum of Natural History in recognition of the importance of his work on "Oceanic Birds of South America" published in two volumes in 1936 The presentation speech was written by Dr Frank M Chapman, in his absence, it was read by Dr Ross G Harrison, former chairman of the committee on the Daniel Giraud Elliot fund Dr Chapman emphasized the long period of training had by Dr Murphy in preparation for his monograph of 1,245 quarto pages on the subject He spent several years in various regions of South America and when, later, the collection of 7,853 ornithological specimens, gathered by R. H Beck during four and one-half years, reached the American Museum, Murphy. in the words of Dr Chapman, "was the one man qualified by experience, training, and desire to interpret this collection With most of the species represented, he was familiar in life, and he had visited a large part of the area, whence they

came. Thus his field studies, added to Beck's collections, made the ideal laboratory combination.

"To the systematic treatment of all forms concerned, there was added an exposition of Murphy's discovery that oceanic birds are subject to the same kind of environmental control as seals, sea-turtles, and even fish The part played in distribution by the temperature of water as well as air, the influence of wind and of currents, and the effects of insular isolation are also considered Full biographies, when available, are given with each species, and long-standing biologic problems like that presented by the confusing relations of the steamer ducks are satisfactorily treated "

The John J. Carty Medal

The John J Carty Medal with accompanying honorarium was bestowed upon Professor Edwin G Conklin of Princeton University under the citation "Zoologist, Cytologist, and Embryologist; Philosopher, Teacher, and Scientist, student of life and of growth from lowliest beginnings to highest consummation " The presentation speech was made by Dr O E Buckley, chairman of the committee on the John J Carty fund In it he referred especially to the friendship between General Carty and Dr. Conklin and to the influence the one had on the other, especially of Conklin's philosophy on Carty's thinking In the words of Dr Buckley

Conklin has pointed out that man's future development lay not in the evolution of man as an individual but in the evolution of society—the building of an harmonious body out of cooperating human elements, with man adding to his own power the forces of nature Carty saw in the telephone system of his creation the nerve system of that society—his telephone wires and radio channels were the nerves to provide communication among the specialized human elements of the peaceful and efficient social organization yet to be evolved

In gratefully accepting the medal and award, Professor Conklin expressed great surprise and pleasure that he should have been chosen as the recipient He appreciated thoroughly the act of the committee which had thus associated his name with that of General Carty, whom he had known for many years and had greatly admired and respected He mentioned the discussions he had with General Carty on many subjects, and the stimulus he had derived from them and from the impact of General Carty's personality.

F E. Wright,
Home Secretary

POWER FROM PULVERIZED COAL

Potential reductions in the approximately two million barrels of fuel oil used annually by the forging industry by its replacement with pulverized coal are shown to be possible in a recent survey made for Bituminous Coal Research, Inc, by Battelle Memorial Institute, Columbus, Ohio This has focussed renewed attention on pulverized coal—its history and its utilization

As the world's principal source of heat and power, coal is the very foundation of our present industrial civilization. World consumption is about one and one half billion tons annually, and there is little doubt that coal, both in solid and in pulverized forms, will long continue to be the basic source of the country's energy requirements. Best estimates indicate enough bituminous coal to last this country 4,000 years at the present rate of consumption, or 2,000 years if all our present energy demands were to be supplied by coal

Pulverized coal, sometimes also called powdered coal, is adaptable to many industrial uses Coal in this form—any coal whose moisture content has been re-

duced and which subsequently has been ground to an extremely fine powder in special mills—has several advantages in certain applications.

Work Began a Century Ago

The technology of pulverized coal has been the object of study by engineers and scientists for more than a century. Experimental work conducted as early as 1831 by the Englishman, John Samuel Dawes, establishes him as an early pioneer in pulverized coal firing. However, to the Englishman, T. R. Crampton, must go the chief glory of the pioneering period. In 1873 he read a paper before the British Iron and Steel Institute which expressed views which were fundamentally correct. The deductions that resulted from the five years of experimental work which preceded his presentation were unusually sound. He was strongly insistent on the importance of the size of the fuel particles and of the intimate mixture of air and coal. His experiments were concerned with the use of pulverized coal in steam boilers and puddling furnaces.

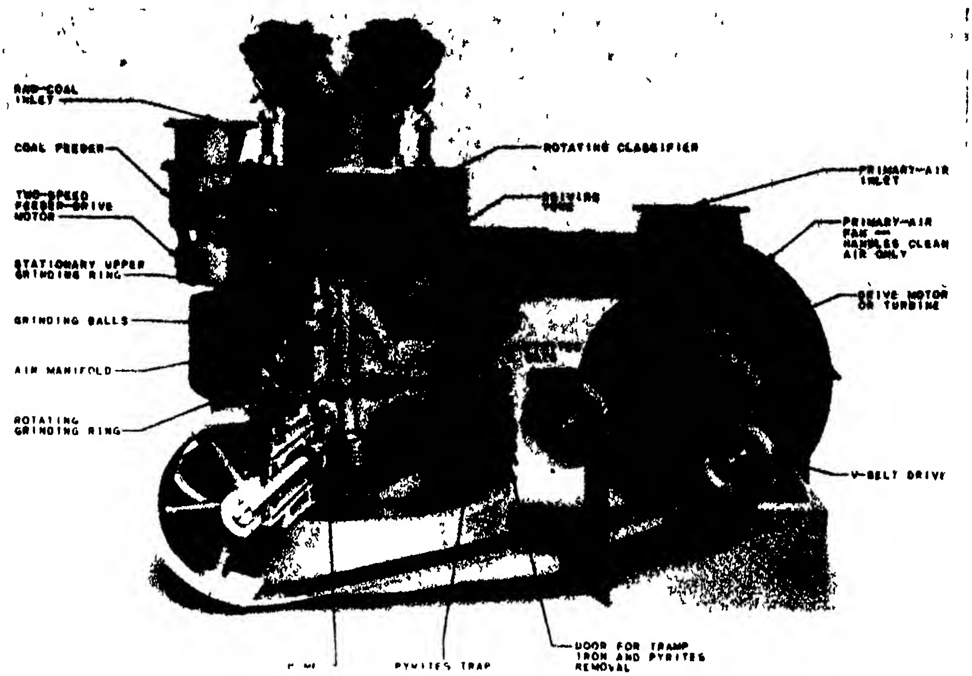
It is reported that the numerous failures which attended the early history of fuel applied in pulverized form resulted in some contempt and ridicule in engineering circles. The heavy deterioration of refractory linings, the rapid coating of boiler surfaces with an impervious insulating layer of ash slag, irregularity of fuel control, the constant fear either of spontaneous combustion or explosion, both of which frequently occurred in these early experiments, all combined to insure failure.

Faults were gradually overcome. By the turn of the century pulverized coal was being used successfully in rotary cement kilns, where its success has been so marked that it can be claimed to account for about eighty per cent. of the world's output of Portland cement. Its successful application to various metallurgical furnaces and stationary boilers occurred in the 1915–1925 period.

Metallurgical Applications Varied

Metallurgical applications of pulverized coal include its use in forge, melting, annealing, billet heating, piling, rever-

METALLURGICAL APPLICATIONS OF PULVERIZED COAL
INCLUDE ITS USE IN ROTARY MELTING FURNACES, SIMILAR TO THE ONE SHOWN. THE CURVED PIPE IN THE FOREGROUND SUPPLIES THE COAL AIR MIXTURE.



BALL-RACE PULVERIZER, WIDELY USED IN THE PULVERIZING OF COAL

beratory and puddling furnaces, as well as the open hearth In 1929 there were 200 pulverized fuel plants installed in the United States in connection with the iron and steel industry, and they served 2,500 furnaces which consumed 3,000,000 tons of bituminous coal annually One Pennsylvania plant used pulverized coal from 1913 to 1939 as a fuel for melting steel in the open hearth furnace

Although domestic heating units are the major sources of the smoke nuisance in large cities, the use of pulverized coal in metallurgical furnaces and for boiler firing can contribute to smoke abatement because of its smokeless combustion.

Since 1920, when the first large boiler in this country was successfully fired with pulverized coal, its use as a fuel for large steam boilers in industrial and public utility plants has accelerated. To-day, pulverized coal is the predominant fuel for this use.

Virtually Complete Combustion

A lump of coal of one cubic inch, having six square inches of surface for exposure to burning, by pulverization may be reduced to upwards of 50,000,000 small particles, collectively presenting an assumed 2,000 square inches of oxidizable surface If one visualizes the burning of lump coal on a grate, it is apparent that combustion passes through a number of phases, and the rate of combustion will depend on the rate at which the oxygen in the air can be brought into contact with the coal.

Coal in the lump usually is slow burning, but its rate of combustion can be accelerated greatly by the adoption of forced draft. Even so, unconsumed carbon sometimes remains in the ash and unburned fuel is carried to the stack. On the other hand, the minute particles of pulverized coal are discharged through a burner into the furnace complete with

the air required for complete combustion, and virtually perfect combustion can be obtained Although at first thought it might appear that the pulverized coal would have a higher combustion rate, the rate is similar, per cubic foot of furnace volume, to that obtained with solid coal in stoker firing

Furnaces are often fired directly from individual pulverizer mills with success equal to that attained by direct-fired steam boiler furnaces However, it is often desirable to pulverize at a central plant and distribute the coal to individual furnaces There are various ways of achieving this distribution Pulverized coal when mixed with air can be made to flow through standard pipe over distances up to 5,000 feet, and the most common types of distribution utilize this property

Wider Utilization Foreseen

Power directly from coal has long been the dream of engineers, and technologists at Battelle Memorial Institute, under the sponsorship of Bituminous Coal Research, are investigating this possibility along with other applications of pulverized coal

As a further application, one writer has suggested that Germany may attempt to devise ways to ultilize pulverized coal as an aircraft engine fuel because of her difficulty in retaining adequate supplies of petroleum This recalls the interesting fact that when Diesel, about 1890, was planning the type of engine which now bears his name, his primary idea had been to employ coal dust as fuel After several years of experimental work, the engine which he constructed proved to be adapted to oil fuel but not at all to coal or even gas, and so for this, as well as economic reasons, its ultimate development was directed toward the utilization of oil

Although unsuccessful as a locomotive fuel twenty years ago, advances since that time indicate that pulverized coal will be an important locomotive fuel of the future Anticipating further advances in coal science and technology, one may expect still wider utilization of this fuel of our ancestors by our progeny, and its advantages of complete combustion, perfect control and flexibility will contribute much to its expanded use

R O Stith

HUNTING FOR GRANDPA BUMPS

The Redbeds of Northwestern Texas, containing the remains of many ancient land vertebrates, have been worked for seventy years past But until the discovery of Grandpa Bumps only one large ancient amphibian had been found in these deposits. This was Eryops, a rather advanced type, familiar to museum visitors and to readers of elementary texts I was consequently much surprised when, a dozen years or so ago, I ran upon fragments representing a large new labyrinthodont The material was very scrappy—bits of backbone and limbs and, most common, chunks of bone about the size of one's fist. These bore, on one surface, the pitted sculpture common on the skull bones of early amphibians and on the other, the broken-off bases of very large teeth

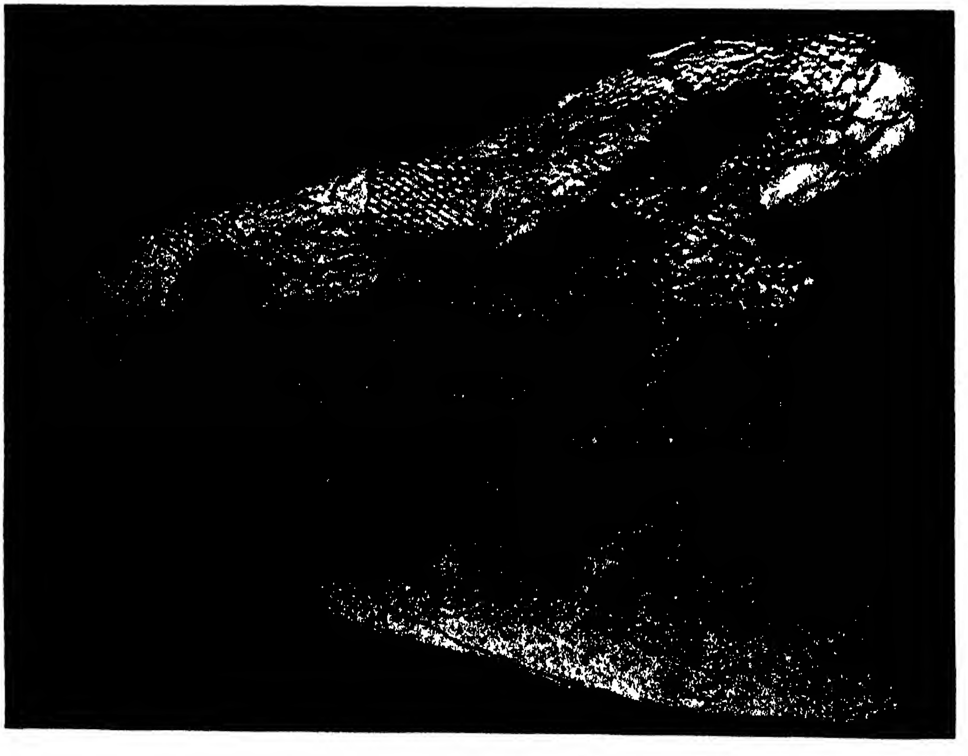
Obviously the animal was a new one, and since the remains were from a horizon lower than those normally worked in Texas, the chances were very good that it might be a more primitive form than those common in the Texas beds. The characteristic "nuggets" were surely representative of thickened swellings on the animal's muzzle which, because of their stout build, survived the vicissitudes which had destroyed the rest of the skull It was therefore reasonably given the scientific name of Edops —"swollen face" To those of us who

searched for his remains, however, the creature has been known by the more homely name of "Grandpa Bumps."

The first scraps found of Grandpa Bumps only whetted our appetites for more. We desired a skeleton, if possible, or at least a skull—for many of the most important features of amphibian evolution are revealed in cranial morphology. For some years he eluded us. More and more scraps were found, but never a skull or skeleton, or even any two pieces that would fit together.

Finally, one spring a few years back, when I found it possible to get to Texas for a month, and to take with me assistant preparator R. V. Witter, from the Harvard Museum, it was decided that our main purpose would be to trace Grandpa Bumps to his lair, and devote our energies to exploring the formation in which alone his remains were to be expected. We did so; but it was a dreary business. The sediments of this horizon are unusually barren and many a day we would return to camp without a bone of any sort worth saving—and with no trace at all of our venerable amphibian friend.

Came the last day before I must take the train back to Cambridge. We had resigned ourselves to failure as regards Edops, and comforted ourselves in the thought that we had at least found a few other interesting specimens. That morning, as a last try, we stopped our car at Terrapin School. Behind the white schoolhouse the bank dropped sharply into a natural amphitheatre, perhaps a mile across. Its center was a flat mesquite-covered plain. But its margins, fifty feet or more high, showed plenty of rock surfaces in which fossils might be found. So at the bottom of the slope



RECONSTRUCTED SKULL OF EDOPS—"GRANDPA BUMPS"

we parted, Witter to work round the left side, I to the right, with the understanding that if all went as usual we would meet on the opposite side at lunch time.

On my side of the hollow I found plenty of clays and shales and gravels to be looked over, many a bank to climb and gullies to explore. But no trace of bone of any sort. It was a hot June day, with a temperature that was probably about 100° in the shade, and considerably over that in the white glare from bare rocks in the still air of this depression By noon I had reached the far side of the hollow, weary, discouraged and thirsty, longing for a return to the shade of the car and a deep draught of canned tomato (civilization's greatest gift to the Southwest).

But Witter hadn't arrived The task was not completed. So I kept on along the wall of the amphitheatre, looking (but not too hopefully) for bone and (hopefully) for Witter around each corner.

Two o'clock. Still no Witter. This was really too much. I abandoned the search and struck back across the flat and through the mesquite for the car.

There, not more than a hundred yards from our starting point, the missing Witter sat, cool and happy, fitting together pieces of bone. Within a few minutes of the time we parted he had come upon the place where the skull of a great amphibian, now broken into fragments, had lain And he had spent the rest of the morning right there, searching for the pieces, large and small, which had washed away from the spot and been buried in the gravels and clays nearby. When such pieces as could be readily fitted in the field were put together, we saw that we had a new type of amphibian skull—and that this new type was the long-sought-for Grandpa Bumps.

Grandpa returned with us to the laboratory. A few pieces of his skull (indicated by hatched areas on the accompanying photograph) had apparently washed too far down the gullies for us to find, but most of it was present, and except for the tip of his snout we were finally able to make out almost every feature of his cranial anatomy; the details are given in a paper by Witter and the writer in a recent number of the *Journal of Geology.* The skull is nearly a yard in length and is, as far as I am aware, the largest known among Paleozoic amphibians. More important is the fact that it proved, as we had hoped would be true, to be more primitive than that of the typical Redbeds labryrinthodonts. Because of excellent preservation (as contrasted with the imperfections of Carboniferous material), Edops can thus boast of having the most primitive of adequately known amphibian skulls From the well-preserved braincase it proved possible to obtain an excellent cast of the brain cavity. This has been described in the *Journal of Comparative Neurology* by Dr. Tilly Edinger and the writer. It appears to have enclosed a type of brain more primitive than that of any living tetrapod and offers valuable clues as to the course of brain evolution in land vertebrates. Grandpa Bumps was a modest and retiring animal; but at long last he did his bit toward the advancement of science.

Alfred Sherwood Romer

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AUGUST, 1943

WHAT WE DO NOT KNOW ABOUT RACE

By Professor WILTON MARION KROGMAN

DEPARTMENTS OF ANATOMY AND PHYSICAL ANTHROPOLOGY, THE UNIVERSITY OF CHICAGO

WE are, in this discussion, going to focus upon race and problems of race purely from a biological angle. The approach may be illustrated by an experience the writer had some dozen years ago In 1930–31 it was his privilege to study in the Galton Laboratory of Applied Eugenics at London University. On the first day, as he ascended the stairs to a second-floor classroom, he saw on the landing-wall in front of him a huge illustration, an enlargement of a cartoon that had appeared in *Punch*. Two English country gentlemen were standing beside a blue-ribbon bull, and one gentleman said to the other, "We know about breeds in animals, but what about ourselves?" The theme of this discussion is, then. What about breeds in our biological selves? We shall discuss these selves not in individual, but in group terms In a very real sense what we do not know about human biological groupings may become positive knowledge if it outlines future avenues of research If we recognize a darkness we also recognize a need for light.

The *first* "don't" is simply this: we are not sure—at least we do not agree—what actually constitutes a biological race in man. In 1871 Charles Darwin, in "The Descent of Man," expressed the problems of racial classification quite clearly:

> Every naturalist who has had the misfortune to undertake the description of a group of highly varying organisms, has encountered cases . . . precisely like that of Man, and if of a cautious disposition he will end by uniting all the forms which graduate into one another, under a single species, for he will say to himself that he has no right to give names to objects which he can not define.

Darwin represents one extreme: there is but one race, the *human race*. One may study the literature on human racial classification and go to the other extreme, wherein no less than 150 species, each with sub-races, are postulated.

In 1735 Linnaeus, the great Swedish naturalist, gave Man the scientific name he to-day still bears—*Homo sapiens* (the "wise man"). Let us analyze ourselves biologically: an expanded cerebral cortex that makes of us a reasoning animal; a protracted period of infancy and childhood that enables us to be a learning animal; a facial skeleton reduced in size so that we have a physiognomy instead of a snout; a forelimb that is freed from locomotion so that a forepaw has become a hand, a spinal column, viscera, a pelvic girdle, and a hind limb, that are reasonably well adapted to an upright posture and bipedal locomotion. In this general morphological pattern all mankind is truly one: one genus, one species. In all important and major bodily details we are one—in brain, in peripheral nerves, in heart, in blood and blood vessels, in all

viscera, in muscles, and in skeletal architecture

But there do exist differences which are, as it were, superimposed upon this basic ground-plan There are differences in skin color, in eye color, in hair color and hair texture, in head shape, in nose and lip shape, and even in limb proportions. These differences are obvious, they are external, and we have recognized them for thousands of years. On the basis of skin color, principally, we subdivide *Homo sapiens* into three major groups: White, Yellow, Black Scientifically we may designate these as *H. s caucasoideus, H. s mongoloideus, H s negroideus,* respectively [1] Each of these groups—in practice we often call them "stocks"—is a sub-species, and each has certain distinctive morphological features which, taken singly, are not necessarily mutually exclusive, but which, taken in combination or complex, do tend to set the groups apart. Actually, this same general conclusion applies to sub-species in lower forms as well.

So far, so good. Now let us observe one of these stocks—the Caucasoids—in greater detail. Within this sub-species, in Europe, there are groups which, originally on a geographical basis, precipitate out as more or less recognizable entities: Northwest, Central, Southwest, Northeast, Southeast To these types—and we here use a simplified terminology—have been applied the names Nordic, Alpine, Mediterranean, Baltic and Dinaric, respectively. They fall into place in our scheme as follows:

H. s. caucasoideus nordicus
" " " *alpinus*
" " " *mediterraneus*
" " " *balticus*[2]
" " " *dinaricus*[2]

In this stock break-down we come, finally, to the groups that the anthropologist generally terms race; they are, in taxonomic fact, sub-sub-species, or varieties. Do they exist to-day? The answer must be a qualified affirmative; that there may be local, isolated, probably highly inbred groups of Alpines, for example, in certain Swiss valleys Similarly there may be small regional groups of the five Caucasoid varieties we have named But there are no peoples or nations in Europe who are pure Nordics, pure Alpines, or pure anything else. In substance, there are *no pure races:* there are only populations in which two or more varieties are intermixed, and that intermixture began before the dawn of European history. Therefore, what we term races in Man are poorly defined, because they are not—as in races in lower forms—homogeneous; they are intermixed, hybridized, diffused. That is why one man says "no races," the other "many races." The first is appalled at the difficulty of disentangling intermingled varieties; the second holds that secondary or composite groups warrant racial status

The problem of mixture above mentioned—of hybridization so that "racial purity" is non-existent—renders it impossible to ascribe genetic homogeneity to the races we have set up. Suppose we took ten persons classed as Nordics (five males, five females), and ten persons classed as Mediterraneans (five males, five females) and bred within each group. we could not guarantee, and we would not expect, that the offspring would be all Nordics and all Mediterraneans, respectively. In the Nordic × Nordic we might get some short, brunet, long-heads; in the Mediterranean × Mediterranean we might get some tall, blond, long-heads About all we might reasonably expect is that the Nordic offspring would tend more to tall blondness, and the Mediterranean offspring to brunet shortness. In other words, the groups we call races are genetically heterogeneous; they include genes that are gen-

[1] Some anthropologists feel that these merit specific ranking.

[2] There is reason to believe that these were originally variant combinations of the three preceding, basic types.

eralized, and that are also shared more or less equally by one another

Actually, how have we in practice set up a racial classification? The first method is that of *somatological inspection:* we look at a group and find that, on the average, they are short, slender, dark-complexioned, long-headed, wavy-haired, and their habitat is circum-Mediterranean; thus *H. s caucasoideus mediterraneus* comes into being (Italians, Spanish, southern French, etc) The second method is by *biometric analysis* Here a certain portion of an entire group —a random sample—is measured and described precisely If mathematical investigation shows that this sample (and hence the group) is statistically homogeneous and significantly different from all other groups, then the group under consideration is termed a race "A biometrician's concept of race in man is derived primarily from the statistical study of samples . . His methods are essentially descriptive and they do not presuppose any particular theory of individual or racial heredity."[3] The end result of both of these methods is the *l'homme moyen,* or type, the hypothetical individual who represents the averages of all the individuals in the group (e g , John Bull, Alphonse, Hans, Uncle Sam are caricatured types of an Englishman, a Frenchman, a German, an American).

In summary, our *first* "don't" recognizes that the groups we call human races are, taxonomically, sub-sub-species As in all lower forms the differences which set these races apart—at such a taxonomic level—are not clear-cut and precisely defined. As far as Man is concerned, we focus upon a relatively few apparently stable characters and then accept them as having a definitive and diagnostic value In doing this, however, we do not diverge radically from accepted zoological princples at sub-sub-specific levels for lower animal forms generally. At species level distinctions are quite clear; below that they are dim in the haze of variability

The *second* "don't" is found in the fact that we are uncertain how stocks and races arose, i e., when in human evolution they appeared and the mechanism involved in their emergence. We are pretty well satisfied that Man, as a primitive hominid, probably arose some five million years ago, more or less, as the result of a divergence from a generalized anthropoid form which gave rise to Man and the Anthropoids as we to-day know them But that accounts for Man as Man—how about the White Man? The Yellow? The Black? Well, we are not really sure There are suggestive finds, but nothing more The first White Man may possibly be seen in Galley Hill man, resident in England some 400,000 years ago; the first Yellow Man is suggested by Weidenreich to date to Sinanthropus, the man of Peking, China, of about a million years ago; the first Black Man may date to Rhodesian man in Africa, 100,000(?) years ago—certainly he was present in southern Europe at Grimaldi, some 25,000 years ago We repeat, we are not sure of the import of these finds in terms of the time-appearance of stocks Two things must be borne in mind . first, the finds are random and inconclusive because we do not have sufficient numbers to know range of variation; second, the characters commonly diagnostic of stock or race are those of soft parts not preserved in the fossil record

If stocks, or sub-species, be of doubtful origin, how about races, or varieties? Here we are more in the dark than ever. We can answer only that Mediterranean-type crania are found well defined by the opening of the Neolithic, about 10,000–15,000 years ago, Nordic-type crania are reported in the Swedish Neolithic. The time element in stock and race emergence is approximate, nothing more.

Now that we have considered when they arose, let us take up how they arose.

[3] G. M. Morant, in "Race and Culture," p. 24, 1934. Royal Anthropol Inst., London.

One of the most intriguing theories is that of Sir Arthur Keith,[4] who feels that the endocrines may have played a role: "The transformation of man and ape . . . is determined by a common growth-controlling mechanism which is residual in a system of small but complex glandular organs" As Keith surveys the role of the pituitary in acromegaly, the thyroid in achondroplasia, the adrenals in pigmentation, the gonads in secondary sex characters, he sees analogies with certain statural, osteologic, cranio-facial, skin conditions in the stocks of mankind, e g, the big-boned, rugged-skulled Caucasoid shows a possible pituitary dominance; the flat-faced Mongoloid shows a possible thyroid dominance; the dark-skinned Negroid shows a possible adrenal dominance[5] Keith offers these endocrine associations more as suggestions than as absolute statements They undoubtedly exist as factors, but to-day we recognize the endocrines as so complex, so interrelated, that any statement of uniglandular dominance must be taken with tremendous reserve The exact role of the endocrines in human evolution and in the appearance of stocks and of races is in the realm of conjecture

In our present knowledge of human evolution we assume that sometime, somewhere, there existed a generalized protohuman or hominid species that had, potentially at least, all of the morphological characters found to-day in all of mankind This species must have been genetically fairly homogeneous, though probably inherently variable

From this species there arose through mutation, recombination, selection, migration and isolation, the stocks and races as we now recognize them.

The *third* "don't" resides in the inadequacy of our knowledge concerning heredity in Man. Specifically, we do not know the precise mechanism whereby traits diagnostic of stock and race are transmitted.

One of the most obvious methods employed by the physical anthropologist in studying human heredity is to analyze the effects of race mixture.[6] Here it is assumed that the traits that "show up" or persist in a cross are "dominant" For example, when a long-head is crossed with a broad- or short-head it is apparently the broadness or shortness that dominates; similarly, nasal breadth dominates over nasal narrowness, lip thickness over lip thinness, and so on. But all this is not genotypic (genetic constitution) it is phenotypic (physical appearance) We do not know the exact genetic pattern involved; we know, for the most part, only what the end-result "looks like" Moreover, we are observing the operation of only a dozen or so pairs of thousands of pairs of genes in Man. It is this dozen or so for hair, eyes, nose, lips, skin, and a few other traits, that we rely upon for stock and racial diagnosis; all the others are presumably constant for all groups.

Strandskov has given us an excellent summary of known gene distribution in Man[7] Color blindness is a sex-linked recessive, with gene (*cb*) on the X-chromosome; color blindness is present when normal color vision (*Cb*) absent Ability to taste the chemical phenyl thiocarbamide is an autosomal recessive with (*T*) for tasting, (*t*) for non-tasting. In the A–B blood groups we find inheritance by triple allelomorphs, as follows:

Blood group	*Gene combination*
AB	I^A I^B
A	I^A I^A or $I^A i$
B	I^B I^B or $I^B i$
O	ii

[4] Keith, A, "The differentiation of Mankind into racial types." *Ann. Rep Smith. Inst.*, pp. 443–53 Wash, D C 1921

[5] About 1775 John Hunter concluded that the original skin color of Man was black, and in 1921 Keith reaffirmed that statement.

[6] T W Todd, "Entrenched Negro physical features." *Human Biology*, 1 (1) 57–69. 1929, W. M Krogman, "The inheritance of non-pathological physical traits in Man." *Eugenical News* 21 (6): 139–146. Nov.–Dec., 1936.

[7] H. H Strandskov, "The distribution of human genes," SCI MON, 52: 203–215, March, 1941, "The genetics of human population," *Am. Nat*, 76: 156–164, 1942.

In the M–N blood groups we find the following:

Blood group	*Gene combination*
MM	A^m A^m
MN	A^m A^n
NN	A^n A^n

Biologically the knowledge of these few genetic patterns is important because the mechanism is identical for all human beings; the inherited traits cut straight across stock and race; e.g., *all* blood groups and their genes are found in Whites, Yellows and Blacks, though in varying percentage combinations. It is possible that these combinations may have some value in racial distinction, just as does skin color, etc., but as far as transfusibility is concerned (allowing for blood groups) all human blood is alike.[8]

We are certain that physical characters diagnostic of race and stock are hereditary: they arose genetically, via mutations and subsequent isolation, they have been perpetuated genetically in varying combinations. We know, for example, that there is an average of "one mutation for every 50,000 individuals per generation" (Strandskov), and that most of these mutations are of indifferent or even negative survival value. The few that are positive are transmitted and over a long period of time have entered into complexes and combinations which differ from stock to stock, and within stocks from sub-type to sub-type, from variety to variety. We are slowly but surely learning the genetics of Mankind in terms of his many physical-type variants.

A *fourth* "don't" is really a corollary of the third, namely, we realize that discrete traits have a hereditary basis, but we are still not sure which of these traits are relatively stable and which are easily modifiable, so that the first set is useful in classification, the second extremely limited in use.

In studying problems of racial analysis Hooton[9] has outlined three categories of physical traits in Man: those that are non-adaptive, those that possess an acquired stability, and those that are easily modified. We may summarize these three categories as follows:

There are certain features which appear to act as heritable entities, either as unit characters or with multiple factors. These comprise in general hair-color and eye color, form of hair, eye-fold, nose, lips, ear, incisor teeth and vertebral border of scapula, head breadth, face length, chin prominence and prognathism, and limb proportions, including intra-membral, inter-membral and trunk-limb ratios. These physical characters are non adaptive, stable, fixed, and may quite reasonably form the basis of the assessment of racial distinctions. Furthermore, certain combinations of these traits, varying within natural boundaries, result in the establishment of subgroups within each major classification.

We come now to several traits which have in the course of time been functionally modified and by selection have become more or less stabilized, at least their variability is of intra racial rather than inter-racial magnitude. Here we may include skin color, shape, size, and proportion of the malars and the palatal arch, head height and brain volume, and possibly certain calcaneo gastrocnemic relationships. The list is small and its import uncertain, the farther we go in our study of individual growth patterns and their probable relation to presumed racial criteria the more we must allow for modifiability. It may be that the stability is spurious, merely a transitory phase in the creation of an ultimate pattern dictated by constitutional vicissitudes.

Finally, there are a number of bodily features so directly susceptible to health, diet and food habits, climatic factors, gait, exercise, occupation and other miscellaneous influences as to render them useless as racial criteria. Here must be mentioned height, weight, thoracic dimensions and proportions, nasal proportions, facial width, proportions of forearm and hand, relationship of vertebral column and pelvic girdle, and shaft proportions of femur and tibia.

It may be finally emphasized that we must, in problems of racial interpretation, pay general attention to the sum total of all bodily traits, but specific and critical attention to the non-adaptive bodily characters, for these are transmitted regardless of the multifarious and complex extraneous factors of the environment. All things equal, it is not one, not two, but the

[8] It is implied in the phrases "blood-relation" or "blood will tell" that somehow blood is a carrier of familial relationship. The blood group is itself inherited, but blood, per se, is not a vehicle of genetic transmission.

[9] E. A. Hooton, "Methods of racial analysis." *Science*, 53: 75–81. 1926

majority or all of the traits, in unique combination, which really constitute racial or group differences But until we know more of the heredity of the several traits, of the effect of the growth pattern upon these traits, we can not truly assess them in terms of non-adaptivity, acquired stability, or modifiability [10]

For the last thirty years we have had reason to doubt the stability of certain morphological features, as in the cephalic index studies of Boas and his students, wherein significant generational differences were observed when foreign-born parents and American-born Jews and Sicilians were studied. In recent years Shapiro[11] has suggested that instability is characteristic of a majority of Man's physical racial traits He studied three generations: (1) "sedentes," native parents born and still resident in Japan; (2) Japanese-born (of these parents) who migrated to Hawaii in their late 'teens, (3) Hawaiian-born children of these immigrants The anthropometric battery comprised twenty-eight measurements with twenty-one derived indices and twenty-two observations When the first two generations were compared it was found that they differed significantly in all traits measured and observed as follows: male, 72 4 per cent ; female, 67 9 per cent. As between the second and third generations the corresponding differences were 55 2 per cent. and 42 9 per cent., respectively These differences are progressive from sedentes, to immigrants, to Hawaiian-born, but whereas between sedentes and immigrants disproportionate changes occur, between immigrants and Hawaiian-born proportionate changes are the rule The progression is apparently a real one, relatively unaffected by age-changes or changes in occupational status The causes of the changes are twofold: the immigrants probably constituted a subgroup of the sedentes population from which they were drawn; the new environment (of Hawaii) provided a stimulus toward change and some inbreeding intensified the variant exemplified by the immigrants. But the changes are, of course, limited in extent—the Japanese in Hawaii, as long as they marry within their own group, will always be Japanese; biologically they will not, can not, become Hawaiians, even though there might be some environmental convergence

We now regard human races as much more plastic than we formerly did But our concept of plasticity is basically a genetic one. There are a multitude of genes which encompass the entire range of human physical characters Plasticity resides principally in recombinations of these characters Recently Mills[12] has shown that there is another phase to this plasticity, an environment (diatetic) aspect. He found that vitamin B requirements (thiamin, pantothenic acid, and pyroxidene at least) are much higher in the tropic than in a temperate zone, and that growth and development are inhibited by inadequate B intake under tropical living conditions Here is an example where growth-pattern and hence adult configuration (taken as a racial criterion) is modifiable by the food environment We are just beginning to learn how a temperate-zone White man may possibly adjust to a subtropical or tropical habitat, but for one fact we know there are 100 questions that are still to be answered

The *fifth* "don't" is found in the functional aspects of Man· we know little about the physiology of race-types. We have studied racial metabolism, pulse-rate, respiration-rate, and so on, but these analyses are not so much tests of race-groups *per se* as reflections of conditions under which they live There is no reason, really, to assume difference in kind, rather only differences in degree. If we relate body-type to body-function then distinct group differences can not be

[10] W. M. Krogman, *op. cit*, pp 144–145.

[11] H. L Shapiro (with F S. Hulse), "Migration and environment " Oxford U. Press, N. Y. 1939.

[12] C. A. Mills, "Climatic effects on growth and development, with particular reference to the effects of tropical residence." *Amer. Anthropol*, 44: 1–13 1942.

expected, for body-type cuts across stock- and race-lines.[13]

There is another phase of the functional problem which requires classification, viz, so-called "racial immunities" and "racial susceptibilities" For example, the peoples of North Europe are said to be prone to whooping cough, resistant to goiter and cretinism, the peoples of Central Europe fall prey to goiter and cretinism, but withstand pulmonary diseases; the American Negro succumbs to tuberculosis, diseases of heart, lungs and kidneys, and more successfully combats malaria, yellow fever, measles, scarlet fever and diphtheria[14] Are these really *racial* differences? Probably not The answer is more likely to be found in problems of relative isolation and exposure, and most certainly in considerations of socio-economic standards There are, so far as we know, no genetico-racial biological differences in the organs which will conduce to, or inhibit, organic breakdown under the onslaught of disease The problem, however, is still one to be explored

The *sixth* and final "don't" is that we do not know of any characteristics, either biological or psychological, that in a given race-cross are superior or inferior. On the biological side there may be one exception, viz, the sickle-shaped erythrocyte which is an autosomal dominant trait (Si) found only among Negroes, to the extent of 4 per cent

Much is being made these days of "race superiority" and "race inferiority" In words of one syllable *there is no such thing*[15] One hears of the woodsman who, on a crowded city street, heard a cricket; he can be matched by the mechanic who in the turmoil of a machine-shop hears a bearing-knock in an engine four rows removed Again, there is the savage whose keen eye sees vast distances or detects a faintly-trodden blade of grass, he can be matched by the scientist who under the microscope sees a new world in a drop of water The ear and eye are common human possessions as far as morphology is concerned—it is the degree of their training that differs. This type of reasoning can be applied to any phase of Man's activities: how he learns and how much he learns is dependent upon his cerebrum and upon the cultural framework within which he learns; the cerebrum is the constant factor, the cultural framework, the variable. The same holds true for "intelligence," however it may be defined and assessed We repeat that biological superiority and inferiority in the stocks and races of man do not exist, and that biologically there is no valid bar to stock- and race-mixture The first generation hybrids are not biologically inferior—it is Society and not Nature that stamps the brand of undesirability

In recent years German anthropologists have, as we know, advanced preposterous claims of Nordic or "Aryan" superiority (*Das Herrenvolk*) Such claims have no basis in fact. They have also claimed that widespread race-crossing ("race bastardization") will have a dysgenic effect ("gene chaos"), leading to various bodily abnormalities and asymmetries. This, too, is far more fanciful than real though Fleming,[16] an English anthropologist, has found some slight evidence of dento-facial disharmonies in Negro-White hybrids crossed with Negro-Chinese and Chinese-White hybrids. But this evidence is not conclusive, for there is no guarantee that growth inadequacies rather than genes

[13] F. Weidenreich, "Rasse und Korperbau" Springer, Berlin, 1927

[14] A Hrdlička, "Immunity as the chief task of future medicine" *Lit. Digest* Dec 9, 1933 (see p. 14); see also J. H Lewis, "The biology of the Negro" U of Chicago Press 1942

[15] Otto Klineberg, "Race differences." Harpers, N Y. 1935. W. M. Krogman, "Is there a physical basis for race superiority?" SCI MON., 51 428–434, 1940, M. F Ashley Montagu, "Problems and methods relating to the study of race. *Psychiatry,* 3 (4): 493–506. 1940.

[16] R. M. Fleming, "Physical heredity in human hybrids." *Annals Eugen*, 9: 55–81. 1939.

are to blame, i.e., that malnourishment has not modified a genetic pattern. As matters now stand the crossing between sub-species or stocks is socially so unacceptable that only lower social strata are involved. It is precisely here that environmental impact and modification—in terms of insufficient and incorrect foods, improper hygiene, health hazards—are at their maximum. We have no adequate basis, therefore, for a true assessment and interpretation of the solely biological effects of stock-crossing. As far as we know the genetics of stocks and races, we need not, *a priori*, expect any biological maladjustment.

This discussion has been pretty much on the negative side—a sort of "hit parade" of scientific uncertainty with respect to race biology: we are not agreed what a race is, we are not sure when and how races arose; we do not know the precise hereditary mechanism in race; we are not sure which physical traits in race are stable, which modifiable: we do not know physiological and immunological features of race-groups; we can not assess race in terms of superiority and inferiority. In very truth we know little about the bio-genetical aspects of race.

Despite the foregoing avowal of inadequate knowledge we venture to present a definition of race that is sufficiently generalized to include the variables of physical type, heredity, environment and habitat:

> A race is a sub-group of peoples possessing a definite combination of physical characters, of genetic origin; this combination serves, in varying degree, to distinguish the sub-group from other sub-groups of mankind, and the combination is transmitted in descent, providing all conditions which originally gave rise to the definite combination remain relatively unaltered; as a rule the sub-group inhabits, or did inhabit, a more or less restricted geographical region.

Certainly the physical anthropologist is not so dogmatic about the clarity of distinction between racial groups as he once was. Indeed, there are those who would deny the existence of human races, and who advocate dropping the term entirely. If the term *race* is purely genetic, and if we do not know the genetic make-up (the genotype) of a presumed race-group, then it follows that we can not define the group genetically, and therefore it does not exist as a homogeneous genetic entity. This argument, as the present writer sees it, while biological on the face of it, stems more from a cultural misinterpretation of the term ("racism"), wherein race and nationalism are confused, than from considerations of presumedly diagnostic morphological characters.

There do exist certain groups which may be put into categories; i.e., there are groups which tend to precipitate out when defined by a certain physical trait-complex. The trouble resides in the fact that the trait-complex has been too rigidly defined, with too little allowance made for variability. The physical anthropologist freely admits that his classification has been based on the phenotype—the few external features used in diagnosis. We are prepared to reclassify upon the basis of the genotype—the basic genetic constituency. In both instances we will have groups called *races*: in the first instance—the present-day method—groups are classified by *what they look like* physically; in the second instance—the emerging bio-genetic method—groups will be classified by *what they are* genetically.

The term race as we use it today is a recognition that group differences do in fact exist. It does not imply, scientifically and biologically, a homogeneity such as demanded by geneticists. When our knowledge of human heredity enables us to classify the peoples of the world genotypically we will gladly accept that classification—we will substitute it for the one we now have. Until then, and with full and complete recognition of all of its many inadequacies, we will use the system at hand.

WINDS OF THE UNITED STATES

By Dr. STEPHEN S. VISHER
PROFESSOR OF GEOGRAPHY, INDIANA UNIVERSITY

ALTHOUGH the winds, aside from tornadoes and hurricanes, are often taken for granted, and are of less popular interest than are warmth, cold, rain, snow, and drought, wind directions and velocity are major causes of the variations in temperature and moisture Indeed, this summary of the winds logically should have preceded the discussion of regional contrasts in the United States of temperature and precipitation presented in the preceding articles of this series (SCIENTIFIC MONTHLY, September, November, 1942, April, 1943.)

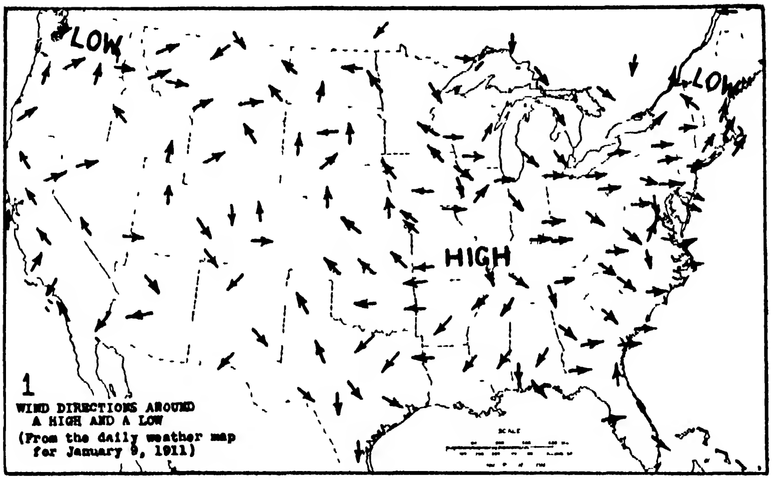
Winds of seven great types occur in the United States, although most of those we feel belong to one type This common type is the winds which blow spirally out from the eastward moving masses or areas of relatively high air pressure called Highs, or which blow spirally into similarly moving areas of relatively low air pressure, known as Lows. As the Highs and Lows move across the country, the spiralling winds which they induce come, for any particular observer, successively from various directions When the center of the High is to the west of the observer, northwesterly winds prevail; when its center passes over, a calm prevails for a time, followed by southeasterly winds. As a Low passes from due west, the wind directions change from south to north. If the centers of the High or Low pass to the north or south of the observer, somewhat different wind changes occur.

The wind directions reported by the Weather Bureau observers on a recent winter day are shown in Map 1, which is a copy of part of a daily weather map On that particular day there was a large High near the center of the country and Lows in the northeast and northwest corners The next day different wind conditions occurred, as the High moved to the Atlantic coast and the northwestern Low moved over Dakota.

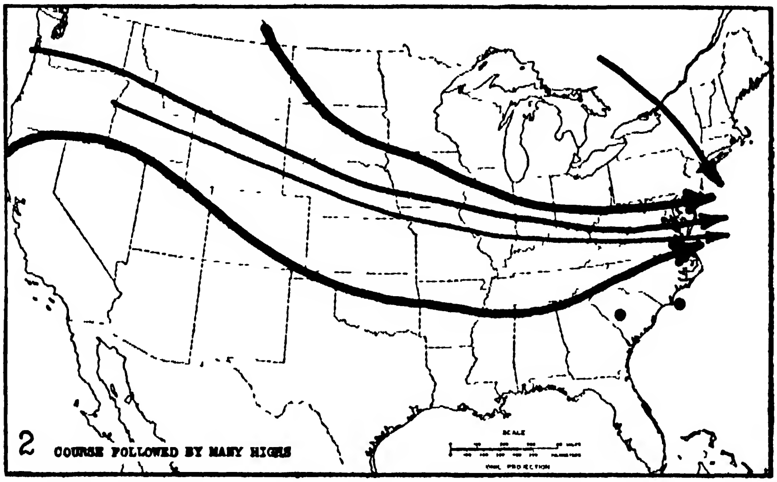
The Highs and Lows move eastward, but usually not due east for a great distance. Instead they often move southeast or northeast. The "paths" followed by many Lows and Highs are shown in the second and third maps The lines which are exceptionally heavy represent roughly courses along which relatively many of these cyclonic disturbances travel These maps are based on official Weather Bureau ones as to the courses followed, but the relative frequency of Highs and Lows along each course is partly based on studies by Van Cleef

Maps 2 and 3 show that, on the average, the Lows move somewhat northward in crossing the United States, while the Highs move into lower latitudes Indeed many Highs move rather rapidly southeastward from Western Canada, occasionally bringing cold weather in winter as far south as the Gulf coast.

The courses followed by Highs and Lows depend upon three chief influences. Their general eastward movement is due to the Westerlies, which prevail overhead most of the time in the United States, pushing the cyclonic masses eastward, or east-north-east That the Highs move, in general, east-southeast instead of east-northeast, shows that the prevailing Westerlies (which blow from the west-southwest) are only one of the great influences affecting the course followed by the Highs and Lows. A second influence is that, as the result of the continual blowing of the Westerlies, air



1
WIND DIRECTIONS AROUND A HIGH AND A LOW
(From the daily weather map for January 9, 1911)

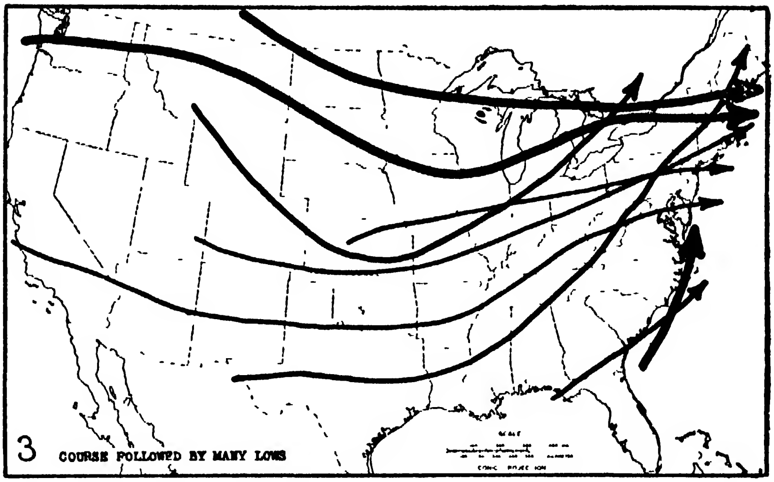


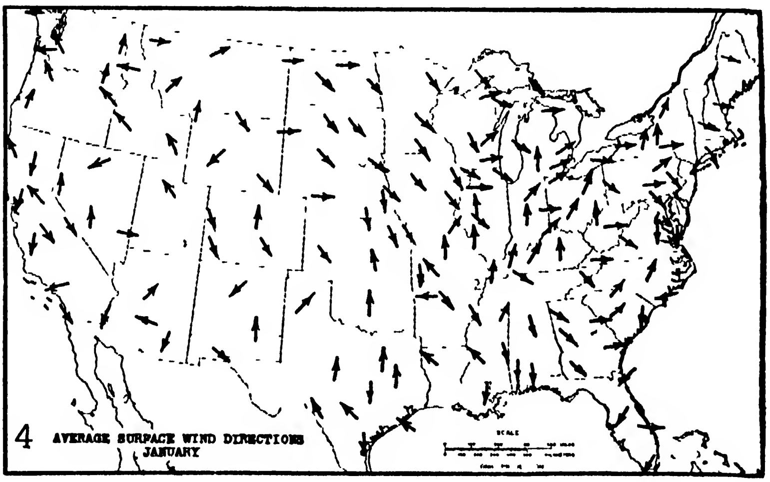
2 COURSE FOLLOWED BY MANY HIGHS

piles up in polar and subpolar latitudes From time to time some of this air must return to lower latitudes or else finally much of the air would accumulate near the Poles Our Highs are masses of subpolar air which have broken away and are moving east-southeastward across the United States.

A third influence which affects the courses followed by the Highs and Lows is air pressure conditions prevailing at the time in surrounding areas. The relatively high pressures which develop in summer time over much of the oceans in middle latitudes, and over much of the land in winter time, appreciably affect wind directions

Maps 4 and 5 show the average or net wind directions in the lower air. They are copies of the Weather Bureau maps in the "Atlas of American Agriculture" by J. B Kincer. Although each part of the country has winds from almost all directions, with such a rapid succession of changes that most people do not realize that one direction is more common than another, nevertheless these maps show distinct trends. During July, southerly winds prevail in most of the East, while in much of the West, northerly winds are

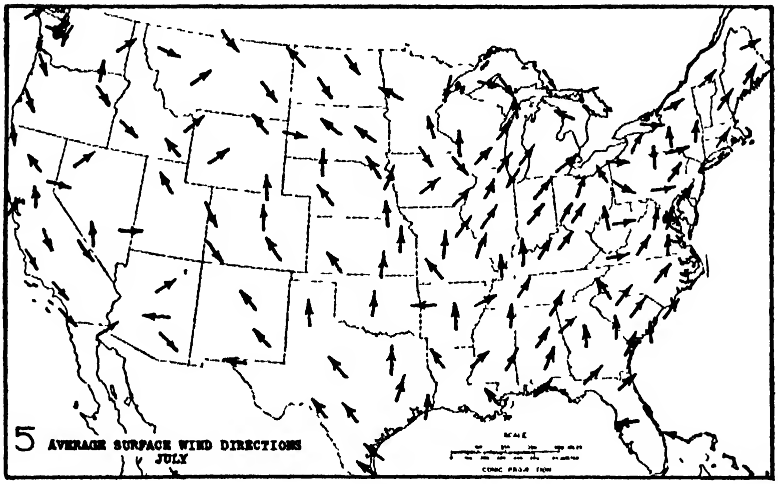




common. Conversely in winter, northerly winds are most common in the East and southerly winds in the West. Thus the average directions of the winds are an outward clockwise spiral in winter and in inward counterclockwise spiral in summer. This is the same way they blow out from a High and into a Low (Map 1). The continent thus, on the average, has relatively high pressure in winter and relatively low pressure in summer.

The tendency for the air to blow from relatively cool water bodies toward the warm land illustrated by Map 5 is much more strongly illustrated by the land and sea breezes, the third chief type of wind in the United States. Such winds are restricted to coastal areas and to times when the land is relatively hot Lake breezes are often strong in hot weather on the southern and eastern shores of the Great Lakes, and are characteristic in summer along the Atlantic and Gulf coasts, and to a lesser extent on the Pacific coast. Land breezes, toward the water body, are just as frequent, but are less noticed, as they occur at night or in the early morning when the land is cooler than the water.

Map 6 shows the average velocity of the wind, miles per hour. It is a shaded copy of a colored map by Kincer in the



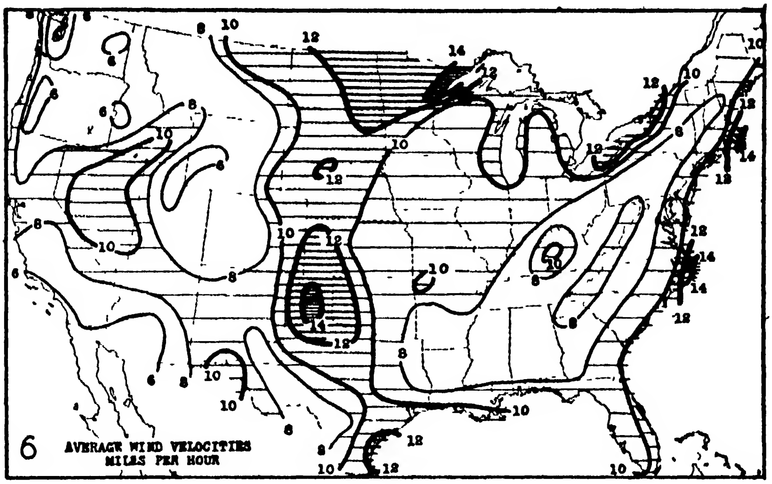
"Atlas of American Agriculture." It reveals that the average velocity is relatively great along the immediate Atlantic coast, in the Great Plains, and bordering the Great Lakes. In these areas the average velocity, approximately 12 miles per hour, is about 50 per cent greater than in much of the East or West. The higher average velocity along the coast and on the Great Lakes is partly due to the less surface friction there. The smooth grassy Great Plains are relatively windy partly for the same reason. The low average wind velocities in much of the West are partly associated with the protected valley situation of most of the Weather Bureau instruments which measure the velocity. Mountain tops there usually have considerable wind.

The higher velocity on the coasts is partly due to the presence during part of the year of land and sea breezes. The higher average velocity in the Great Plains is partly due to the eastward slope of that area. Wind, like water, tends to flow down slopes.

The relatively low average velocity in the extreme southwestern part of the country is partly due to the fact that during midsummer that area is under the influence of the high pressure subtropical calm belt. That calm belt affects the Southeast less notably partly because thunderstorms are there more common.

Mountain-Valley Breezes

The fourth main type of wind in the United States is the so-called mountain and valley wind or breeze. These are local winds of little or no significance on level land. In hilly or mountainous areas, however, they often are of appreciable importance Cool breezes often blow down the valleys at night, sometimes commencing soon after sundown. During the day, on the other hand, the normal breeze direction is up the valley. These changes are due to differences in the rate of heating and cooling associated with the topography. Hillsides upon which the early morning sun shines heat up much sooner than do the lowlands, which perhaps are still in the shade, and which often contain much more dew or frost which must be evaporated before the overlying air can become warm. When the hilltop or upper hillsides become relatively warm, a slight rarification of air occurs which results in a breeze in that direction. Conversely at night, the hilltops and shaded slopes cool more rapidly than the nearby lowlands, with their thicker blanket of air. The


6 AVERAGE WIND VELOCITIES MILES PER HOUR

cold air, being relatively heavy, drains down the valley, sometimes in restricted situations, forming quite a strong breeze

A special kind of mountain wind is the foehn, or chinook, which occasionally is prominent in winter and spring on the eastern foothills of the Rocky Mountains, and on the leeward sides of various other ranges Foehn winds are modified cyclonic winds rather than purely local winds, such as the breezes discussed in the previous paragraph, but their modification is due to the mountains and hence they are often called mountain winds When cyclonic winds ascend a mountain range swiftly enough to have a considerable share of their moisture condensed by the cooling the ascent causes, the first big step in the formation of a hot, dry chinook has occurred. The clouds formed from the condensed moisture, together with the latent heat liberated by the condensation of moisture, interfere with the amount of cooling which the ascent should cause Hence the air commences its descent on the leeward side of the mountain warmer than its altitude justifies As it descends rapidly, it is warmed by compression and is rendered relatively dry, and hence cloudless. The sunshine associated with the cloudless sky facilitates further heating Sometimes a chinook reaches the foothills twenty or even forty degrees warmer than the surface, causing a rapid evaporation or melting of the snow, and a sudden rise of temperature

Chinook winds increase the utility of the western Great Plains for stock-raising, as their frequent removal of the snow cover facilitates winter grazing. By removing the snow and drying the soil, the chinooks also often permit spring wheat to be sown earlier than in areas beyond their influence Early sowing is advantageous for spring grains partly because the more plant growth that has occurred before the hot and sometimes dry summer arrives the better.

The beneficial influence of the cool breezes which commonly blow down the valleys of rugged regions in hot weather are best illustrated in the tropics In Honolulu, for example, building sites at the lower end of mountain canyons are far more valuable than nearby sites which are not bathed by cool valley breezes at night Many sites in the eastern United States are appreciably affected, however, by such breezes. The writer recalls with gratitude the cooling evening zephyrs which regularly blew in hot weather down a valley which crosses the Cornell University campus, which is

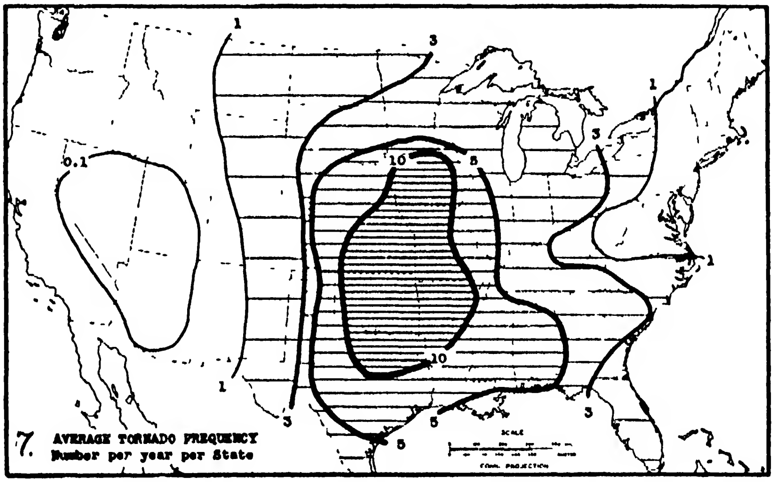
on a bench far above one of the Finger Lakes. Several faculty homes are so situated as to benefit from this breeze.

Convectional Winds

The fifth important kind of wind in the United States is the convectional. The most prominent convectional winds are associated with thunderstorms, but lesser ones cause much of our cloudiness, and convectional eddies cause dust whirlwinds. The conspicuous type of thunderstorm wind is a blast of cool air which often attains gale velocity, the thunderstorm squall The updraft of warm air which makes the thunderhead grow now sometimes strongly affects airplanes, airships and gliders

Convectional winds develop when the lower air, next to the ground, is much warmer than that not far above. Hence in the United States they are most common in summer. In the Southwest, however, thunderstorms, and also the convection-formed cumulus cloud, are common in autumn and spring, and are not lacking in winter A map showing the annual frequency of thunderstorms is given in the November article of this series, Map 8, p 451 It shows that in much of the Southeast thunderstorms occur on 60–80 days a year, two or three times as often as in most of the North In the West, thunderstorms occur rarely near the Pacific coast, about ten days a year some 300 miles east of the Pacific, but on some fifty days a year in the central and southern Rocky Mountains.

Thunderstorm squall winds cause property losses of nearly ten million dollars a year, on the average, in the United States



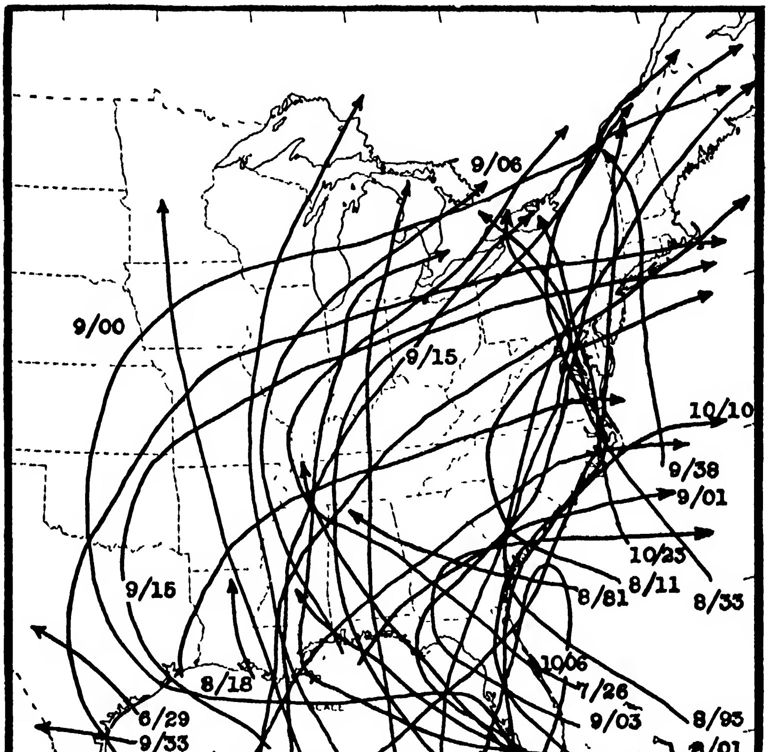
7. AVERAGE TORNADO FREQUENCY
Number per year per State

Tornadoes

Tornadoes, violent whirling winds, often incorrectly called cyclones, occur frequently in the United States and at least occasionally in much of the rest of the world In the approximately 2,800 tornadoes recorded by the Weather Bureau in the United States during the twenty years 1916–1935, 5,224 people were killed and property losses in excess of $230,000,000 were sustained. Losses in excess of $100,000 were caused by 375 of these tornadoes; losses in excess of $1,000,000, by thirty Three caused reported property losses of $24–43 millions each. One of these three and two others killed from 103 to 689 people. The worst was that of May, 1925, in southern Illinois.

These violent storms occur in all of the States and Canadian provinces and in Alaska They affect so small a strip that

the chances that any spot will be hit are small. Even in the area where they are most common, the chances that an average farm will be crossed in a century are less than one in a thousand Many farms are crossed without damage to the buildings; many buildings are demolished without the loss of a human life.



8. SOME HURRICANE TRACKS
Dated as to month and year

Tornadoes are violent whirls started by opposing winds and associated with sharp vertical contrasts in temperature They start in the clouds and extend to the ground only where the air near the surface is relatively warm, as compared with the higher air. Tornadoes rise above the surface again whenever the surface air is relatively cool Hence, as to time of day, destructive tornadoes occur chiefly in the afternoon or early evening. The few destructive nocturnal tornadoes occurred on hot sultry nights. Weather Bureau experts can successfully predict the general occurrence of tornadoes, but not their exact location As they affect such a tiny fraction of the large area in which they might occur, the benefits derived from official forecasts were more than outweighed by the suspension of business fear and even heart failures, induced. Hence forecasts are no longer issued.

Map 7 is an original one based on State average official data presented otherwise by J B. Kincer of the Weather Bureau. It shows that tornadoes are more than ten times as frequent near the center of the country as in the Northwest or the West. They are least common in the

most arid region, where, however, violent almost tornado-like dust whirlwinds are frequent

Tropical Cyclones

The seventh great type of wind is the tropical cyclone. They vary in intensity from mild disturbances which yield much rain, but little wind, to violent hurricanes. They enter the United States chiefly from the West Indies and the Gulf of Mexico, but occasionally one progresses northward along the western coast of Mexico, affecting southern California or Arizona. Storms which developed in the western Pacific as tropical cyclones also enter the United States from the northwest, as Lows. Indeed a considerable share of our Lows are of tropical origin In addition to Lows of tropical origin entering the United States from the west or northwest, an average of about twenty tropical Lows a year enter the South or pass northward near the Atlantic coast. Of these, three on the average are hurricanes and two have gale winds (32–75 miles per hour). (Visher, *Monthly Weather Rev.*, Vol. 58, 1930, pp 62–64.)

Map 8 shows the courses followed by various hurricanes which entered the United States. Many of them ceased to be violent storms before they had progressed far over the land, but quite a number caused damage far from the coast, and well out of the tropics. Especially disastrous American hurricanes with the reported loss of life are as follows: 1881, August, coast of S. Carolina and Georgia, 500; 1893, August, coast of Carolina and Georgia, 1,000; 1893, October, New Orleans, etc., 2,000; 1900, September, Galveston, 6,000; 1915, August, Galveston, 280; 1915, September, New Orleans, 275, 1926, September, Florida-Mississippi, 399, 1928, September, Cuba, Florida, 3,000; 1935, September, Florida, 300, 1938, September, Long Island, New England, 682.

Reported property loss was highest in the New England storm, estimated at $400,000,000 The Galveston 1900 storm did an estimated damage of $30,000,000. The Florida hurricanes of 1926 and 1928 caused great tangible property loss, and in addition punctured the Florida boom, causing sharp decrease in property values. Tropical cyclones which lack destructive winds, but which cause very heavy rains, sometimes more than 20 inches in a day, do much unreported damage by causing severe soil erosion. (Visher: Torrential Rains and Soil Erosion, *Jour. of Geology*, Vol. 50, 1942, 96–105.)

THE BLACK LACQUER MYSTERY OF THE GUATEMALA MAYA INDIANS

By Dr. F. WEBSTER McBRYDE

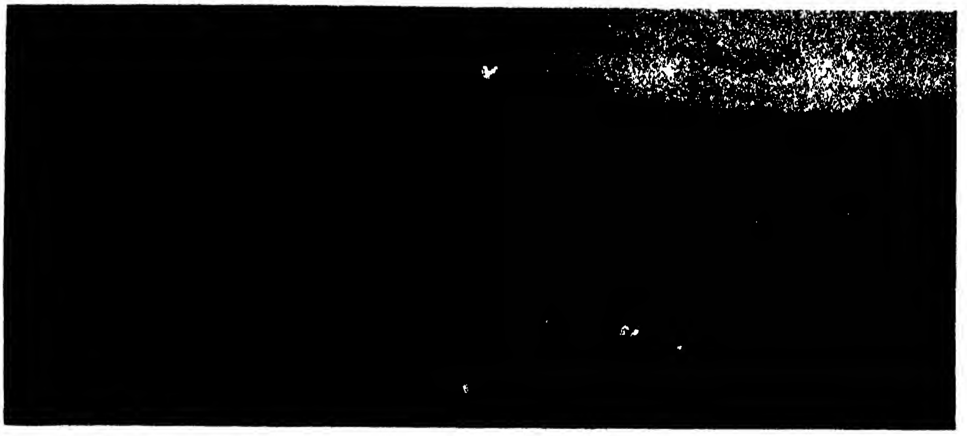
SENIOR GEOGRAPHER, MILITARY INTELLIGENCE SERVICE, WAR DEPARTMENT, ON LEAVE FROM THE DEPARTMENT OF GEOGRAPHY, THE OHIO STATE UNIVERSITY

FOR years I had seen the shiny black gourds with their delicately incised traceries depicting bright-colored birds and beasts and flowers sold in Indian markets throughout Guatemala. The natives call them *jícaras*, and use them extensively as cups and bowls for their coffee, corn gruel and other drinks. I knew the gourds, some round, some oblong, grew on the calabash or gourd tree (*Crescentia*), common in the drier regions of Central America, and that the dyeing and carving was done in Guatemala by the Indians of the town of Rabinal. But every inquiry I made concerning the source of the beautiful black lacquer brought forth a shrug and a comment to the effect that the process was a secret unknown even by other natives outside of that very village.

Some said the dye was derived from an insect, no one knew what kind. According to a widespread rumor, an American piano manufacturer had offered a reward of $10,000 to any one who could discover the secret process. Though I discounted this story from the first, I became more and more interested in the mystery of the black lacquer. It was not, however, until my fifth Central American expedition that I was able to include Rabinal in my itinerary, early in 1941. And my troubles really began only after I had arrived there.

During my interviews with the Indians regarding their crops, the study of which had brought me to Guatemala on this occasion, I asked a number of men about the lacquer. Invariably they evaded the question, or said they knew nothing about it, that they only farmed, while others worked in lacquer and would tell no one how they did it. Even the officials of the village, who were usually most helpful in anything I needed in my work, said they did not know the magic nor could they find out for me. During the course of the day, I noticed that one of the *regidores* who was assigned to me as an assistant became more and more friendly. He wanted to know all about the United States, and I answered his naïve queries as fully and as graphically as I could. I have always worked with these people on a basis of friendship, never offering money or any kind of bribe for information, and have found this to be the best approach. As the Indians are usually very congenial and have an excellent sense of humor, a few jokes and cigar-

MAP OF THE GUATEMALA AREA
SHOWING THE LOCATION OF THE VILLAGE OF RABINAL, WHERE THE BLACK LACQUER MYSTERY OF THE INDIANS WAS REVEALED.



THE SETTING OF THE VILLAGE OF RABINAL

THE VILLAGE LIES IN AN OPEN VALLEY JUST LEFT OF THE CENTER OF THE PICTURE. THE CLIMATE IS RATHER DRY, AND THE VEGETATION IS MADE UP MOSTLY OF THORN-BUSHES AND CACTI. THE HIGHER MOUNTAINS ARE COVERED WITH PINE AND OAK.

JÍCARO, GOURD OR CALABASH TREE

THE COMMON DRINKING VESSEL, JÍCARA, OF THE GUATEMALA INDIANS LITERALLY GROWS ON TREES. THE WHITE ARROWS POINT TO TWO OF THE GOURDS. THE MOST FAVORABLE HABITAT IS THE LOWLANDS, DRY AT LEAST PART OF THE YEAR. HENCE, THE PACIFIC COASTAL PLAIN, THE EASTERN LOWLANDS AND THE INTERIOR BASINS AND DEEP RIVER VALLEYS, SUCH AS THAT OF RABINAL, ARE THE REGIONS WHERE MOST OF THEM ARE TO BE FOUND. OFTEN THEY ARE INTERSPERSED WITH CACTI AND SPINY BUSHES. NOTE THE PINEAPPLE-LIKE EPIPHYTES GROWING UPON THE BRANCHES

ettes in most cases will put them in the mood to answer any reasonable questions.

It was encouraging indeed when my newly acquired young Rabinal friend offered to take me to meet the "oldest and wisest" Indian of the village, who was a *brujo*, or medicine man As usual, when I was introduced to this patriarch, we talked first in generalities, not rushing headlong into the business at hand I asked about the days and months of the year according to the ancient Maya calendar, which I found to be still in use there as in certain other Indian areas of Guatemala That day was *ahmác*, next *noj*, then *tijáx* (February 15) Those were ancient Maya day-names, 20 to a month, and 13 months The old man soon came to feel that I was no stranger among his people My young companion, pleased and impressed by such favorable developments, explained to the old sage my interest in the black gourds Several men's names were mentioned, and long-winded discussions ensued, involving many trivialities about the characters in question. Finally the *regidor* got up, saying he would take me to a man who would give me the whole process of the gourd-lacquer We bade the *brujo* farewell with much ceremony, then walked to the other side of the village, winding through stony alley-ways between half-hidden thatched houses I had even more than usual the feeling of many unseen eyes following our every move

At the first house where we stopped, the reticent inhabitants said they no longer did lacquer-work. The next family claimed to have none of the insects just then. At length, after our fifth attempt had provoked only suspicion and evasion, we came upon a man who was amicable and cordial in the extreme He seemed to be such an old friend of my guide's that not even a statement of our mission disturbed him in the least. He was working on some gourds when we arrived and, at our request, continued so that I could see the various stages in the process On the dirt floor by his side there was a large basket filled with freshly gathered gourds from the *Crescentia* trees that grow in such numbers throughout the dry interior valleys

Our host picked up one of these *jícaras*, which are light buff-colored and slightly pimpled He sprinkled water on it, then with a large, coarse alder leaf, he began to scour it vigorously Thus smoothed, it was then smeared with a yellowish-

LACQUER SOURCE—A SCALE INSECT
THIS IS AN ADULT FEMALE, ONE-HALF INCH LONG. THE DARK OBLONG OBJECTS BELOW ARE EGGS, LAID IN A COTTONY WEB ON THE TRUNK OF THE JATROPHA, SPONDIAS AND MANGO TREES.

brown wax of the consistency of rather soft butter I did not interrupt at this step to inquire about the insect from which the wax was derived. That could wait. I wanted to see where the black came from It proved to be so simple as to be almost disappointing For the little Indian walked out in his yard to a miniature oven of crudely piled stones, lit a bundle of pitch-pine splints, and started a smudge. Soon there was enough soot in the stone niche to scrape quantities of it into a jar. A little of

SMOOTHING GOURDS FOR LACQUER

A LARGE, ROUGH ALDER LEAF APPLIED LIKE SANDPAPER, WITH PLENTY OF WATER, IS ALL THAT IS NECESSARY TO PRODUCE A SURFACE SMOOTH ENOUGH FOR A POLISH. AFTER A FEW MINUTES OF VIGOROUS RUBBING THE GOURD IS READY FOR THE INSECT WAX. FINISHED PRODUCTS MAY BE SEEN IN THE BASKET IN THE FOREGROUND. THEY ARE PLENTIFUL IN THE LOCAL MARKET, AND OFTEN THEY TRAVEL LONG DISTANCES IN TRADE.

THE BLACK "DYE" THE NATIVES USE IS SOOT

AFTER RUBBING THE LACQUER WAX ON A SMOOTHED GOURD, SOOT IS RUBBED ON AND POLISHED. THE RESULT IS A RICH, JET BLACK WITH A BRILLIANT LUSTER. THE INDIAN IN THIS PICTURE IS USING A SOFT CLOTH AS THOUGH HE WERE POLISHING SHOES. NOTE THE LARGE POT IN WHICH THE SOOT FROM THE OVEN HAS BEEN COLLECTED.

this rubbed on the waxed gourd gave the shiny black finish The carving was done with a knife held in the right hand as the vessel was turned in the left Conventionalized leaves and scallops are favorite designs, and sometimes birds and animals Often they are colored bright red and green I took still and motion pictures of the entire process

"How about the insect?" I inquired "What is it like? Do you have any that I could see?"

Without a word, the gourd-worker disappeared behind a cane partition in a dark corner of his one-room adobe dwelling He returned a moment later with a handful of white, fluffy material that looked like a cottony mass of spider-webbing It concealed many minute oval eggs, and a flat, reddish coccid or scale insect (*Llaveia axin*) about a half-inch long "La madre," he said with a friendly laugh "We call it *nij*" He was amused at my great interest in all his actions and remarks Picking up a finished gourd, he put the white "nest," mother insect and eggs inside, then stuffed some corn husks into the mouth of the vessel "For you," he remarked, handing it to me

"Three months from now, when the rains start in May," the Rabinalero went on, "I will plant the 'seeds' [eggs] Bunches of this 'cotton' containing the eggs are tied to the bases of these hedge-plants that we call 'piñon'" He led me into the patio and pointed to a small tree with shiny green branches I identified it as *Jatropha curcas* L, called "physic-nut" by the British in the West Indies because of the medicinal properties of the seeds It is said to have fish-poisoning value as well The "piñon" is the commonest hedge plant in Rabinal because it is the most desirable host for the scale insect

"During the 'winter' [rainy season]," my informant continued, "these hatch and eat the bark of the piñon Our harvest is September 15 to 20, when they have grown to full size. We scrape off the *nij*, put them in large jars, and cook them in water We boil them for three hours, set the soup to cool till the next day, then beat it and stir it for three or four hours inside the house where no one can see This must be done in the middle of the night If anyone sees it done, the grease will be no good" This yellowish,

COLLECTING SOOT TO BLACK GOURDS

THICK COATINGS OF SOOT ARE SCRAPED OFF AFTER A SMUDGE IS PREPARED WITH PITCH-PINE IN A SPECIAL "OVEN" THE NEIGHBOR STANDING IN THE BACKGROUND IS WEARING TROUSERS MADE OF AN AMERICAN FLOUR SACK ON WHICH THE LABEL IS PLAINLY VISIBLE ACROSS THE FRONT SUCH CLOTHING IS NOT UNCOMMON IN GUATEMALA, NOW THAT HAND WEAVING IS DECLINING

buttery fat was what he had smeared on the gourds It rises to the surface of the water upon cooling and standing, then is agglomerated by stirring. The idea of no one being allowed to see it is

CARVING THE BLACKENED GOURD
THE DECORATION OF THE JÍCARAS IS DONE WITH A SHARP METAL CARVING TOOL HELD STATIONARY IN THE RIGHT HAND AS THE GOURD IS ROTATED WITH THE LEFT THE INCISED DESIGNS SHOW WHITE WHERE THE GOURD IS EXPOSED. OFTEN THEY ARE FURTHER ELABORATED BY BRIGHT COLORS, APPLIED WITH A BRUSH.

a device for keeping the secret of the process

Strictly speaking, then, it is lac wax, commonly used in shellac, and not a true lacquer, which is derived from the sap of certain trees.

Soot is not the only pigment used in the gourd-lacquer craft. *Achiote* (*Bixa orellana* L., usually called *anotto* in English) is a common source of dull red. The finish in both instances is remarkably durable, and repeated washing even in warm water will not remove the color or luster. Only through boiling several times can the lacquer be removed by water

As Rabinal is the only jícara-fashioning village in all Guatemala, so in El Salvador the craft is practiced only at Izalco This is one of the few predominantly Indian communities still to be found in the latter republic In Mexico the chief gourd-lacquer center is Tlacotalpan, in the state of Vera Cruz. There are several trees besides *piñon* employed as host-plants for the scale, such for example as *Spondias lutea,* usually called "jobo," which has a poor plum-like fruit

The species name "axín," sometimes "axí" or "ají," is often applied to the fatty substances as well as to the insect It probably is derived from the old Spanish word "ají" (pronounced a-hée) which was the common colonial term for chile (*Capsicum* spp) There is a strong resemblance between the reddish, oval-shaped, wrinkled insect and small varieties of dried chiles.

It is not unlikely that the ancient Maya Indians coated their beautifully carved and painted limestone buildings, and the decorated lintels of zapote wood, with this waxy substance. Such a suggestion has been mentioned in Urbina's "Naturaleza," quoted by Paul C. Standley in his "Trees and Shrubs of Mexico," which includes several interesting paragraphs about the insect and its host plants In Yucatan, where the Maya reached their final peak of spectacular architectural attainment, the *axín* is commonly cultivated for its wax There is little doubt about the antiquity of the use of the lacquer The tree-gourds were also widely used by the Indians before the Conquest. Captain Oviedo, the first Spanish writer on natural history in the New World, early in the sixteenth century, described fine cups of "higueras" (jícaras) in Darien that had handles of gold, "fit to offer to any mighty king to drink out of without reproach." These had come in trade, mainly from Nicaragua And still today, colorful tree-gourds travel on the backs of merchants to crowded markets throughout the Indian country of Central America.

BOTANIZING IN THE HIGHER ALLEGHANIES

By Dr EARL L. CORE

PROFESSOR OF BOTANY, WEST VIRGINIA UNIVERSITY

FROM the standpoint of majestic mountain scenery and rare or otherwise interesting plant life, there is scarcely a more fascinating area in the entire mid-Appalachian region than is included in the Pendleton County offset in West Virginia's eastern boundary Pendleton is noteworthy in having the most rugged relief of any county in West Virginia, it includes the highest elevation in the State, 4,860 feet, on Spruce Knob, and the lowest elevation in the county, 1,155 feet, making a total difference in altitude of 3,705 feet Geologically, its rocks range in age from Ordovician to Carboniferous, even including two small igneous dikes, providing in a relatively small area (696 sq mi) a most remarkable series of plant habitats The recent completion of a splendid highway system has made this charming mountain country readily accessible to the motoring botanist.

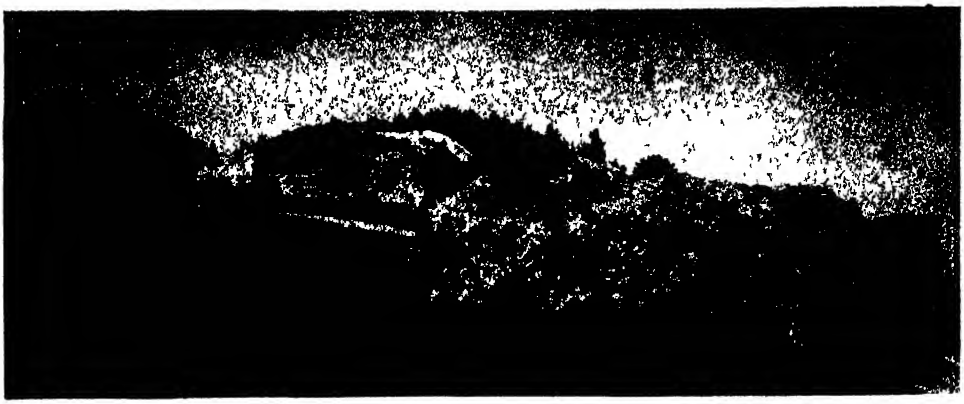
The high crest of Alleghany Mountain forms the western boundary of the county, and the east-bound motorist on U S Route 33 who stops his automobile at the county line finds spread out before him in a tangled mountain mass the alluring prospect of a most delightful excursion

To the left the broad grassy slope of Alleghany rises up and up to cloud-capped Green Knob (4,660 feet), beyond which stretches far to the northwards the windswept, uninhabited expanse of Roaring Plains, a vast monotonous heathland broken only now and then by bold monadnocks of Pottsville Conglomerate or the skeleton of an ancient fire-stricken tree. Footpaths of mountain folk criss-cross the Plains, which every

Paul H Price, West Virginia Geological Survey

FIG. 1. THE TOWERING MASS OF SENECA ROCKS

LIFTS ITS RAGGED CREST NEARLY 1,000 FEET ABOVE NORTH FORK RIVER AT THE BASE.



William E Rumsey

FIG 2. SPRUCE KNOB, THE HIGHEST ELEVATION IN WEST VIRGINIA

summer yield thousands of gallons of blueberries, a crop which investigators at West Virginia University are now attempting to improve by selection and hybridization Here and there poorly drained depressions provide suitable conditions for alder-invested sphagnum bogs, with trailing cranberries (*Vaccinium macrocarpon*) and insectivorous sundews (*Drosera rotundifolia*), studded with mountain holly (*Nemopanthus mucronata*) Occasional gnarled and twisted Table Mountain pines (*Pinus pungens*), pitch pines (*P rigida*) or red spruces (*Picea rubens*) represent Nature's faltering efforts to reclothe the immense waste, whose forests were destroyed years ago by oft-repeated burnings

Dropping down the eastern flank of Alleghany the motorist twists and turns around horseshoe curves or skirts the

Jesse F Clovis

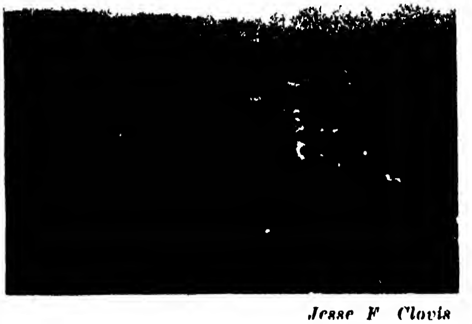
FIG 3. U S. ROUTE 33 REACHES THE SUMMIT OF NORTH FORK MOUNTAIN IN ONE OF THE FEW PASSES THAT CUT THROUGH THE MOSTLY UNIFORM CREST

dizzy margin of deep ravines, with sheer drops of hundreds of feet, finally descending to the headwaters of a tributary of Seneca Creek, which flows between high mountain walls past occasional isolated cabins to Mouth of Seneca, where the towering mass of Seneca Rocks lifts its ragged crest nearly 1,000 feet above North Fork River at the base (Fig 1) The Rocks are composed of White Medina Sandstone (quartzite), which formation, like a great plank set on edge and backed up on each side with a buttress of earth, forms the backbone of a ridge extending the entire length of the county and beyond, like the Great Wall of China The disintegrated fragments of quartzite provide congenial habitats for very few plants, one of the most characteristic being the silvery whitlow-wort (*Paronychia argyrocoma*), which in West Virginia is never found off the White Medina

Driving south along the North Fork River between lofty deep-green Spruce Mountain on the right and towering crag-topped North Fork Mountain on the left, one is afforded innumerable opportunities to examine an interesting ruderal flora Carrying detritus from a bountiful storehouse of infinitely varied limestones, sandstones, shales and other rocks, the river flows over and between beds of gravel and rounded boulders whose instability causes frequent shifts in the course of the stream and prevents the permanent establishment of plant life Scores of species of introduced plants, some of them unknown or rare elsewhere in the State, here find suitable conditions for growth, the pioneer habitats providing freedom from competition Among more common weeds there may be observed the rue (*Ruta graveolens*), toadflax (*Linaria Elatine*), marijuana (*Cannabis sativa*), mole plant (*Euphorbia Lathyrus*), blue thistle (*Echium vulgare*), herba impia (*Gifola germanica*) and cudweed (*Gnaphalium uliginosum*)

Forests against the precipitous river bluffs include, among commoner trees, the arbor-vitae (*Thuja occidentalis*), with the toothache-tree (*Xanthoxylum americanum*) and aromatic sumac (*Rhus aromatica*) as more or less common shrubs, and the curiously distributed Canby's mountain-lover (*Pachistima Canbyi*) now and then forming a ground cover

Just beyond Riverton the traveller may turn right from the paved federal highway to make the nine-mile climb over a narrow but smooth forest road to the summit of Spruce Knob, the highest

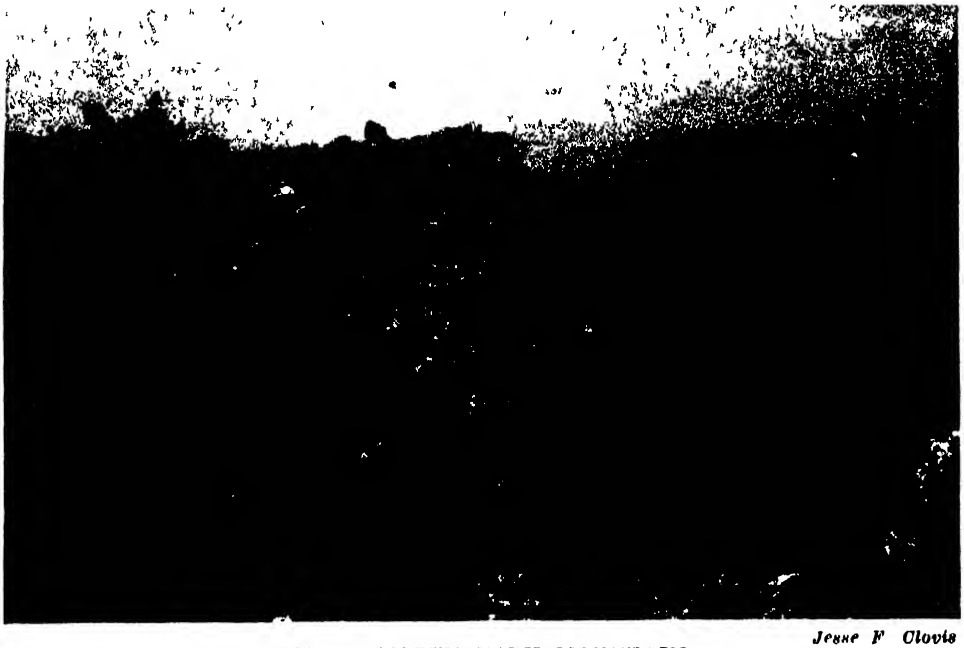


Jesse F Clovis

FIG 4 GERMANY VALLEY

HEMMED IN BY THE HIGHEST MOUNTAINS OF THE MID-APPALACHIAN REGION.

elevation in West Virginia (4,800 feet, Fig 2) Conditions have been greatly improved since 1925 when Rydberg, travelling by automobile to the top of the mountain over a steep rough trail, knocked the bottom out of the crankcase on a protruding rock and had to have his motor hauled in by a team of horses. In a ravine near the Knob Rydberg found a monkshood which he named *Aconitum vaccarum*, because it was said to cause cattle poisoning on the great government pasture range; it does not seem, however, to differ specifically from *A reclinatum*, found in western Virginia almost a century earlier by Asa Gray Near the crest of the mountain is the remnant of a red



Jesse F Clovis

FIG. 5. NORTH FORK MOUNTAIN

TOPPED WITH MASSIVE WHITE MEDINA SANDSTONE IN GREAT LICHEN BLACKENED CLIFFS.

spruce-yellow birch forest, with the white wood sorrel (*Oxalis montana*), here, as everywhere, the most abundant and characteristic plant beneath the spruce trees, while the creeping snowberry (*Chiogenes hispidula*) may be seen In moist open spots American hellebore (*Veratrum viride*) is common The rocky exposed knob yields few species of plants Red spruces occur in patches, their asymmetrical crowns demonstrating vividly the effect of the prevailing winds. Common shrubs are Alleghany Menziesia (*Menziesia pilosa*), mountain ash (*Sorbus americana*), mountain holly (*Ilex monticola*), Canada honeysuckle (*Lonicera canadensis*), wild red raspberry (*Rubus strigosus*), mountain cranberry (*Vaccinium erythrocarpon*), and various species of blueberries. Other plants with a distinct northern range include dwarf cornel (*Cornus canadensis*), bristly sarsaparilla (*Aralia hispida*), skunk currant (*Ribes prostratum*), fringed black bindweed (*Polygonum cilinode*), brownish sedge (*Carex brunnescens*), and the pearly everlasting (*Anaphalis margaritacea*) The animal life is no less interesting Deer are occasionally found Wolves, formerly very destructive to cattle and sheep, have been extinct since about 1890, but there still occur a few black bears, wild cats and varying hares Birds are represented by such species as the veery, winter wren, the Canadian warbler and the golden-crowned kinglet. Rattlesnakes are common

Returning to the valley of the North Fork River, the traveller passes the great barrier of White Medina through spectacular Judy Gap and begins the long, tortuous ascent of North Fork Mountain, twisting over foothills and gaining their summits only to find still higher elevations lying ahead. At one point many motorists come to a halt (Fig. 4), overcome by the magnificent beauty of the great oval of Germany Valley, hemmed in by the highest mountains of the mid-

Appalachian region, with other ranges far away in the background, gradually fading away into the blue. At last the winding road reaches the summit of North Fork in one of the few passes that cut through the mostly uniform crest (Fig 3), topped with massive White Medina in great lichen-blackened cliffs (Fig 5) During the severely cold weather of February, 1899, it is told, a huge rock mass fell out of a precipice and plowed a broad path westward down the mountain-side. The avalanche, occurring just before dawn, awakened the scattered mountain people, who thought it had been an earthquake On the inhospitable rocky ledges *Paronychia argyrocoma* is again found, while the three-toothed cinquefoil (*Potentilla tridentata*) here is common, forming one of the two county records in West Virginia A good stand of many acres of red pine (*Pinus resinosa*) represents the southernmost known station of this valuable forest tree and provides seeds for the State's vast reforestation program (Fig 6). In this wild rock-strewn mountain top the naturalist is startled, too, in beholding the snow-white trunks of paper birch (*Betula papyrifera*), the only colony in West Virginia (Fig 7) Also found here are the purple clematis (*Clematis verticillaris*), mountain maple (*Acer spicatum*), mountain holly (*Ilex monticola*), the large columbine (*Aquilegia coccinea*) and "five-leaved" gentian (*Gentiana quinquefolia*) Rydberg's *Heuchera alba*, the type locality of which is on Snowy Mountain, a few miles to the south, is quite common against North Fork Lily-of-the-valley (*Convallaria majalis*), amazingly, occurs as a native plant in mountain fastnesses on North Fork

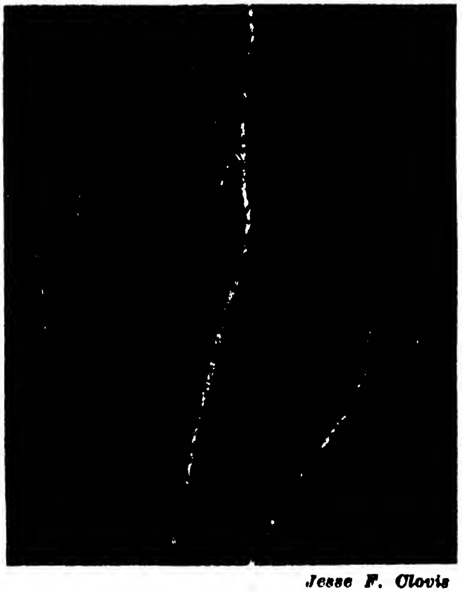
Dropping down the east side of North Fork, the automobilist comes to tidy

U S Forest Service

FIG. 6. RED PINE ON NORTH FORK MOUNTAIN

THIS AREA IS THE SOUTHERNMOST KNOWN STATION FOR RED PINE.

Franklin, Pendleton's county seat, and the valley of the South Branch River Here are broad river bottomlands, with fields of waving corn or hundreds of grazing cattle, Thorn Creek, with its deep ravines and great natural amphitheatre, the Reunion Ground, with the snowy trillium (*Trillium nivale*) in abundance, one of the few localities in the State; and incredible Smoke Hole, where, amidst a land of towering cliffs, sunless canyons and rushing mountain torrents, a few isolated log houses cling precariously to steep mountain sides, the crested coral-root (*Hexalectris spicata*) finds the northernmost extension of its range and the tall larkspur (*Delphinium exaltatum*) its only West Virginia station In a rocky roadside along the valley highway the rusty woodsia (*Woodsia ilvensis*) is found in the only known locality in the State Bur oak (*Quercus macrocarpa*) and swamp white oak (*Q bicolor*), rare elsewhere in West Virginia, are frequent here, and chinquapin (*Castanea pumila*) finds its northernmost State locality Painted cup (*Castilleja coccinea*) carpets moist meadows with scarlet



Jesse F. Clovis

FIG. 7. ON NORTH FORK MOUNTAIN

ON THIS ROCK STREWN CREST THE NATURALIST IS STARTLED AT BEHOLDING THE SNOWY-WHITE TRUNKS OF PAPER BIRCH, THE ONLY COLONY IN WEST VIRGINIA.

Jesse F Clovis

FIG. 8 PRICKLY-PEAR CACTUS

COVERS SHALE BARRENS WITH SUCCULENT SLABS

Through rhododendron-clothed Hiveley Gap, the highway reaches the South Fork, or Moorefield, River Here outcrops of Devonian shales weather to produce the famous shale barrens, inhabited by a bizarre group of rare plants whose nearest relatives often are found in the Ozarks or the semi-arid regions of the Southwest The late sickle-pod (*Arabis serotina*) on the shales near Brandywine flowers two months later than the related *A laevigata;* the remarkable Kate's Mountain clover (*Trifolium virginicum*) rewards the search of the persistent seeker, prickly pear cactus (*Opuntia compressa*) (Fig 8) covers the bare ground with great succulent slabs; the showy evening primrose (*Oenothera argillicola*) provides color for the drab landscape; mountain pimpernel (*Pseudotaenidia montana*) the discriminating botanist separates from the commoner

Taenidia integerrima; the common and widespread *Paronychia fastigiata* shades into *P montana* on the barrens; the velvet "bindweed" (*Convolvulus*) grows erect to unfold its ephemeral white flowers; the hoary plants and yellow flowers of the everlasting groundsel (*Senecio antennariifolius*) add an interesting bit of attraction, Harris' goldenrod (*Solidago Harrisii*) leads the parade of all the goldenrods, sometimes blooming for Memorial Day, while late in the year the shale barren aster (*Aster oblongifolius*) tinges the barrens with pink

At last the botanist begins the long ascent of Shenandoah Mountain, the final stage of his excursion through this happy-hunting-ground Higher and higher, 'round ever-dizzier curves, the twisting highway mounts, as if determined in the last few moments to excel anything yet exhibited, and from the summit, at the foot of old High Top (elevation 4,107 feet), a never-to-be-forgotten scene invites the traveller to return The rare mountain andromeda (*Andromeda floribunda*) is common along roadsides at the crest and *Habenaria bracteata* occurs here in the only reported colony in West Virginia

Resuming his journey, the motorist sets his face eastward into Virginia In his jaunt of less than 100 miles across high and low points through Pendleton County the range of climate had been the equivalent of a trip from the Carolinas to Canada, with a touch of the Southwest thrown in for good measure.

CARRIÓN'S DISEASE

A PUBLIC HEALTH PROBLEM IN PERU

By Dr CALDERON HOWE

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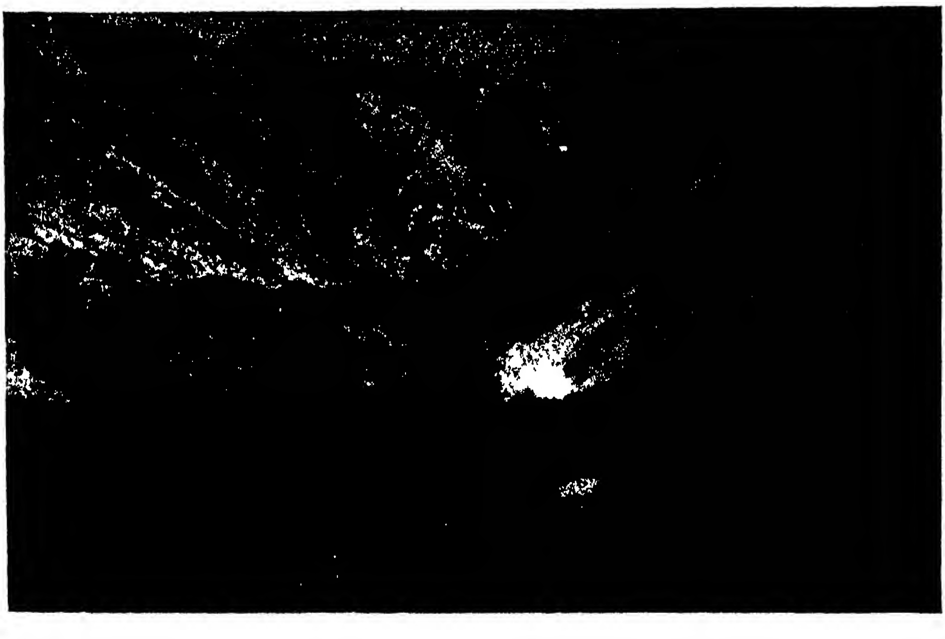
Of all the weird and exotic diseases that occur in tropical and subtropical climates, there are few that can equal "la enfermedad de Carrión" in offering challenging problems to scientists and medical men Carrión's disease includes two clinical entities which are now known to be caused by the same germ, and which have fired the imagination of investigators from many parts of the world

The first of these, *verruga peruana*, has been known for many decades to be endemic in certain districts of Peru, and is said by some historians even to have occurred among the conquering troops of Pizarro It is common in children, and among the natives is often included in the roster of the usual childhood diseases, such as measles, chicken pox, and the rest In a large number of cases, very often among nonimmune adults newly arrived in these endemic areas, the eruption is preceded by the severe and often fatal anemic fever, *Oroya fever,* the other clinical entity of Carrión's disease.

Oroya fever came into prominence for the first time in 1870 during the construction of the central railway from Lima, on the coast, to Oroya, a town situated in the interior beyond the highest point in the Peruvian Andean chain Seven thousand men—according to the legend, one man for every tie in the railroad—are said to have perished in a relatively short time, most of them in an epidemic of debilitating fever, thereafter known as *Oroya fever* The fact that many indi-

BARREN ASPECTS OF PERUVIAN MOUNTAINS
RELIEVED ONLY BY THE NARROW STRIP OF GREEN VALLEY FLOOR



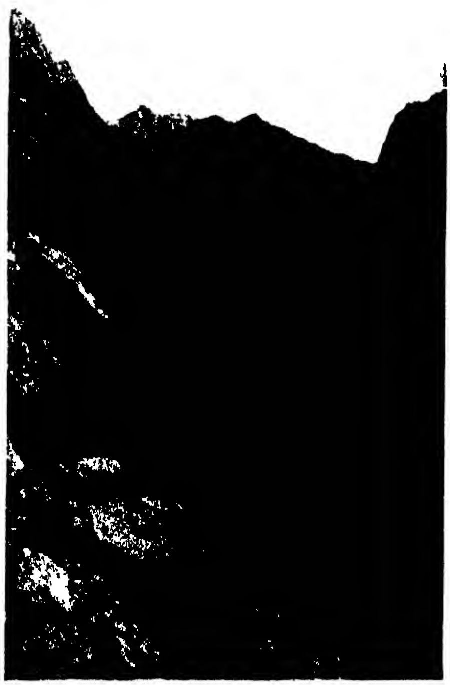
"PUENTE VERRUGAS," OR AS IT IS NOW CALLED, "PUENTE CARRIÓN"
ON THE CENTRAL RAILWAY, SPANS ONE OF THE LARGER "QUEBRADAS," WHICH IS A NOTORIOUS SITE FOR CONTRACTING CARRIÓN'S DISEASE ALTHOUGH NO HUMAN HABITATION EXISTS FOR MILES.

viduals recovered and developed the typical eruption of "verruga" led to the suspicion that this eruption and *Oroya fever* might be related.

On August 27, 1885, a Peruvian medical student, Daniel A Carrión, inoculated some blood and tissue from a human *verruga* nodule into the skin of both his forearms On October 5th of the same year, he died of typical *Oroya fever* This crucial experiment indicated for the first time that the eruptive disease and *Oroya fever* were indeed parts of the same disease, which now has come to be named after this Peruvian national hero The deductions made from his sacrifice have been abundantly confirmed in later years by extensive scientific investigation, both by Peruvian and foreign workers

Carrión's disease is almost unique in having had, until recently, a strictly nationalistic geographical distribution It is seen chiefly along the Pacific slope of the Peruvian Andes, between eight hundred and three thousand meters In 1939, however, it was reported for the first time from Colombia, and in 1940 from Ecuador

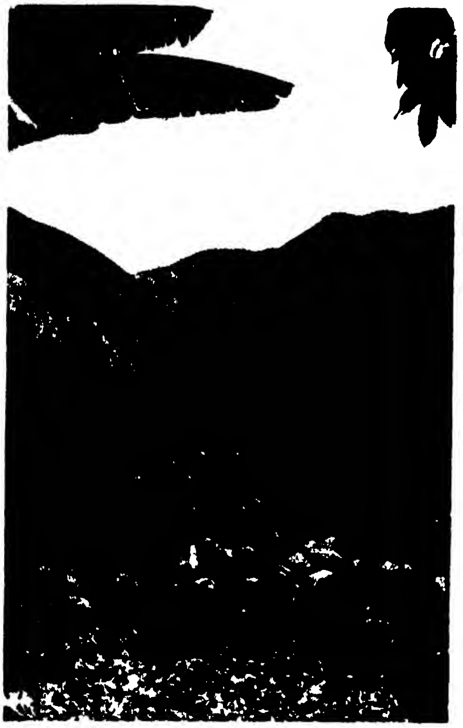
In Peru, the regions where this affliction is endemic are fairly well outlined, and are confined almost solely to the foothills This part of the country often defies description in its ever-changing pattern of deep purples, light ochres, and passing shadows made by the mountain shapes and cloud formations As one climbs from the seacoast, after traversing the narrow coastal plain (perhaps at the mercy of an experienced but over-enthusiastic Peruvian "chofer"), one passes through steep gorges and valleys, the "quebradas" as they are called, between cold and barren hills. The width of the road has narrowed down to slightly more than that of the car, and one holds one's breath as the next hairpin turn is rounded, because of the fairly good possibility of meeting an equally enthusiastic "chofer" coming the other way with far less control over the brakes of his "camioneta" There will then be hair-raising backing and filling with glimpses over the shoulder into the bottomless ravine below as the two vehicles squeeze by each other in a widened place in the road made expressly for such maneuvers



SANTA EULALIA RIVER VALLEY
AT THE UPPER LIMIT OF THE ENDEMIC REGIONS. SCENES SUCH AS THIS RECALL TO MIND THE THEATRICAL EFFECTS OF THE GRAND CANYON

The flora in these regions consists mainly of cacti and low-growing hardy shrubs, notably varieties of the Euphorbia family. During the rainy season in the mountains, from January to April, the peaks are often capped by clouds which may part momentarily to reveal a transient green tinge high up on

the hillsides This warm dash of color will disappear as the rains diminish, leaving the peaks a cold brown-gray hue for the larger part of the year Only the narrow floors of the valleys are cultivated, yielding sparse crops of cotton, coffee, and bananas, the fields being irrigated through the remains of early Inca ditch systems High up on the mountain slopes, miles away, are visible further



SPARSE CROPS
OF COTTON, BANANA AND COFFEE ARE COAXED OUT OF ARTIFICIALLY IRRIGATED AND CAREFULLY COUNTED ACRES OF SOIL.

reminders of the once-great Inca civilization in the form of countless terraces moulded from the sloping terrain, and calculated to squeeze the last corner of tillable soil from the land. It is among the inhabitants of these valleys that the "enfermendad de Carrión" occurs so widely.

Oroya fever itself deserves special mention, as there are few infections that can equal its dramatic swiftness of progression in severe cases It is, fundamentally, a blood-destroying fever, which prostrates its victims by rapidly reducing the normal complement of red blood corpuscles often by more than two thirds Examined under the high-powered microscope, many red blood cells are seen to contain small rod-like and punctate bodies, first described by Dr Barton, in 1905, in Lima These organisms, named *Bartonella bacilliformis*, were later proved to be the germ of Carrión's diseases, that is both *verruga peruana* and *Oroya fever.* The native afflicted with fulminating *Oroya fever* presents an impressive picture—of death-like pallor, marked in spite of deep natural pigmentation, occasionally jaundice, extreme weakness, and often the drowsiness ominous of impending defeat of the natural forces of immunity by the invading microorganism If the patient recovers, he will almost certainly develop the typical eruption of *verruga peruana,* the first signs of which are always eagerly awaited and are welcomed with relief From rough estimates, it is said that about forty per cent of the cases of frank and severe *Oroya fever* terminate fatally

The picture of *verruga peruana*, which may or may not be preceded by *Oroya fever*, is also striking but is far less serious The face and extremities may be covered with bright cherry-red warts, which bleed profusely when tampered with, but which finally disappear without leaving the slightest trace or scar. The eruption may also occur in the shape of a few large painful subcutaneous nodules, or, in other cases, as very small red nodules on the skin, almost uniform in size, scattered in profusion over the whole body. The actual eruption, whatever form it may assume, may last many months and is entirely benign, except

THE GERM OF CARRIÓN'S DISEASE CAN BE CULTURED ARTIFICIALLY
IT GROWS IN FINE WHITE PEARLY COLONIES OF MANY THOUSANDS OF ORGANISMS. SUCH COLONIES, OFTEN BARELY VISIBLE TO THE NAKED EYE, ARE HERE SEEN SUSPENDED IN NUTRIENT MEDIUM

for the discomfort it may cause the patient. When uncomplicated by any extensive secondary infection, it is never fatal. It is, furthermore, not directly contagious, although the germ can be recovered in culture from the nodules.

INCA TERRACES TOWARD THE PEAKS OF THE MOUNTAINS
CALCULATED TO CATCH WATER FROM THE CLOUDS WHILE THESE PERSIST IN THE RAINY SEASON

UNSIGHTLY VARIEGATED WARTS SCATTERED OVER THE EXTREMITIES, AND IDEAL SITES FOR SECONDARY INFECTION. THIS IS THE COMMONEST FORM OF *verruga peruana*.

To transmit the disease from one person to another, requires the intermediary services of the wild sandfly, chiefly the species *Phlebotomus verrucarum*. The fact that the infection can be contracted in the endemic regions only during the hours of darkness and that one can traverse these same regions with perfect safety during the day is explained by the habits of this blood-sucking insect. It is smaller than a mosquito, inhabits the crevices and caves of the barren mountainside, and attacks man and animals only during the night. It is only the female of the species that bites. During the day, sandflies can be picked with ease from the cracks of a stone wall, or be caught in a lethargic state in a dark corner of a native hut. That this insect does carry *verruga* is proved by the fact that the specific germ has on numerous occasions been isolated in pure culture from specimens of *Phlebotomus* caught in the endemic regions. The source of their infection still remains a mystery, and both animals and plants of various kinds have been indicted on many pretexts, none of them proved. From recent surveys, however, it has become evident that an appreciable portion of the native population, namely from four to seven per cent., carry the germ in their blood stream without suffering any of the symptoms of Carrión's disease. These individuals may have had the disease in the past. It is possible that they might be called "carriers," along with active cases of the disease, are the chief source from which sandflies may during the night obtain an infected "blood meal," and so spread the disease to nonimmune persons. It is thus obvious that complete protection can be guaranteed the newcomer in these areas where *Phlebotomus* occurs only in escaping its range either by ascending into the sierra to a point higher than three thousand meters, or by descending almost to sea-level. Even one night's sojourn without protection from fine-meshed bed nets is inviting disaster in the form of almost certain attack at the hands of the ubiquitous *Phlebotomus*. The writer recalls seeing one unfortunate individual, the victim of such an attack during one of the latter's first nights in the endemic zone. He displayed his two forearms literally covered with small reddened dots, the mark

IN CALLAHUANCA, A SMALL VILLAGE OF SEVERAL HUNDRED INHABITANTS, IN THE LOWER PART OF THE SANTA EULALIA VALLEY. TYPHOID FEVER, AND DERMAL LEISHMANIASIS, OR "ORIENTAL SORE," OCCUR HERE IN ABUNDANCE.

of the "titira," as the sandflies are locally known. Such a sight encourages even a Peruvian who has not had *verruga* to hasten back to the coast by sunset.

Many different forms of treatment for Carrión's disease have been tried, some good, others harmful, some traditional, others nearer the scientific. None of them has been consistently successful. There is, as yet, no specific therapy for this infection, as there is, for instance, for syphilis or lobar pneumonia. There is, furthermore, no effective means of immune prophylaxis, such as one can obtain for smallpox or typhoid. It is thus obvious that the disease renders virtually uninhabitable large portions of the country for individuals who have not had either form of Carrión's disease, or who come from regions where it is not endemic. To add to the difficulty, there is no effective method for controlling or exterminating the sandfly, the geographical distribution of which determines the extent of the areas where Carrión's disease is endemic. Its breeding habits offer no opportunity, as do those of the malaria-carrying mosquito, for stopping the cycle of its development, and so diminishing the spread and incidence of the infection it carries.

It is for all of these reasons that Carrión's disease seems at the moment firmly entrenched in its original habitat, and indeed has already shown definite signs of spreading. The recent serious epidemic in Colombia is good indication of this trend. Consequently, it offers a definite and potentially serious public health problem in this age of shifting populations and extensive military movement, and taxes the ingenuity and skill of bacteriologist, entomologist, and "medico" alike.

Photomicrograph, Dr. Marshall Hertig

THE VECTOR OF CARRIÓN'S DISEASE AND EPIDEMIOLOGICAL KING PIN, *Phlebotomus verrucarum*. WHEREVER THE "TITIRA" IS FOUND, CARRIÓN'S DISEASE WILL OCCUR.

SO CALLED "MILIARY" TYPE OF *verruga* ERUPTION WHERE THE NODULES ARE MORE OR LESS OF THE SAME SIZE AND DO NOT BLEED SO PROFUSELY.

CULTURAL INFLUENCES OF PENNSYLVANIA'S MOUNTAIN GAPS

II. IMPROVING THE ROUTES

By Dr. BRADFORD WILLARD
PROFESSOR OF GEOLOGY, LEHIGH UNIVERSITY

The Canals Take over

Beginning as a local means of making detours around rapids or other obstructions along the rivers, the concept of the continuous canal took hold. The obvious routes were along the river valleys through the gaps. Even with the best of locks, hill climbing is not one of the canal boat's greatest accomplishments! The valleys offered the low gradients. Here, too, could be obtained an adequate supply of water essential to the successful operation of the canals. Likewise, construction costs would be reduced in places where deep stretches of river could be joined by canals. Established commercial routes already existed along the rivers, and towns were growing with the attendant concentrations of population.

Since the present discussion is chiefly of Pennsylvania, the Erie Canal may be passed by, though its importance is fully recognized because it alone connected the Atlantic seaboard directly with the Great Lakes. Canals grew westward in the states to our south. The Chesapeake and Ohio Canal followed the Potomac River, others were projected along the James and Tennessee River Valleys. Because of close relations to Pennsylvania, the Chesapeake and Ohio deserves a little more recognition here. As originally planned this canal was to link the seaboard and the Ohio River via the Potomac. Yet, although its value was recognized by George Washington, it was not until 1828 that the undertaking was treated as a whole. Prior to that year it amounted only to short detours around rapids. In the same year that the canal was started the Baltimore and Ohio Railroad commenced to advance its tracks west from Baltimore. Canal and railroad met at Point of Rocks, Maryland. The railroad arrived first, but there was a dispute over the right of way, settled only when the railroad crossed to the Virginia side and drove a tunnel. The canal proved of some importance during the Civil War in the transportation of troops and supplies, and, like the Baltimore and Ohio Railroad, it was an object coveted by both armies.

The canals of Pennsylvania were numerous. Many were associated, either at their beginning or subsequently, with the development of hard coal fields. We refer, of course, to the canals in the east, that is, those crossing the mountains by way of the gap gateways to anthracite.

Because the Erie Canal and those projected along the Potomac and James Rivers were taken as a serious threat to the commerce of Philadelphia, and because the Baltimore and Ohio Railroad was adding to the menace and threatening travel over the National Road, agitation was keen in Pennsylvania for a canal system of its own. Nowhere in Pennsylvania could a canal be economically or feasibly constructed completely across the mountains and plateaus to join the waters of the upper tributaries of the Ohio with those of streams flowing into the Atlantic Ocean. The high, eastward-facing escarpment of the Allegheny Plateau, the Allegheny Front of physio-

graphic literature, terminated western canal-building in the 1820's. An exception might have been made along the upper waters of the West Branch of the Susquehanna River, and the Sinnemahoning River. Not only, however, was this a difficult route, but there was no commerce to call for a canal there. The country was an unknown wilderness as late as 1836. It was in the summer of that year that Henry D. Rogers, first state geologist of Pennsylvania, made a reconnaissance survey from Philadelphia to Lake Erie. Rogers, telling of conditions in the northwestern counties, reports that the country was too wild for penetration even with the pack train. Field equipment and camping outfit had to be back-packed by men hired for that purpose.

Albeit a canal across the Allegheny Front was out of the question, the problem of getting boats up and over was solved. The Pennsylvania Canal came up the Susquehanna and followed as far as Hollidaysburg the Juniata River from its confluence with the Susquehanna north of Harrisburg. For a hundred miles it passed through one water gap after another. At Hollidaysburg the famed Portage Railroad was constructed to transport passengers and to draw the boats themselves up the escarpment. Today, travelers over U. S. Route 22 may mark where the old line climbed the scarp, sketched as it is by remnants of grades ("planes") and the masonry of the ancient roadbed. Once at the top, a similar trip down the west slope brought freight and passengers finally to Johnstown, where the boats resumed the more congenial environment of the canal down the Conemaugh River. A vivid description of this passage of the Alleghenies comes from the "American Notes" of Charles Dickens:

> We left Harrisburg on Friday. On Sunday morning we arrived at the foot of the mountain, which is crossed by railroad. There are ten inclined planes, five *ascending*, and five *descending*, the carriages are dragged up the former, and let down the latter, by means of stationary engines, the comparatively level spaces between, being traversed, sometimes by horse and sometimes by engine power, as the case demands. Occasionally the rails are laid upon the extreme verge of a giddy precipice, and looking from the carriage window, the traveller gazes sheer down, without a stone or scrap of fence between, into the mountain depths below. The journey is very carefully made, however, only two carriages travelling together, and while proper precautions are taken, is not to be dreaded for its danger.
>
> It was very pretty travelling thus, at a rapid pace along the heights of the mountain in a keen wind, to look down into a valley full of light and softness, catching glimpses, through the tree-tops, of scattered cabins, children running to the doors, dogs bursting out to bark, whom we could see without hearing, terrified pigs scampering homewards, families sitting out in their rude gardens, cows gazing upward with a stupid indifference, men in their shirtsleeves looking on at their unfinished houses, planning out tomorrow's work, and we riding onward, high above them, like a whirlwind. It was amusing, too, when we had dined, and rattled down a steep pass, having no other moving power than the weight of the carriages themselves, to see the engine released, long after us, come buzzing down alone, like a great insect, its back of green and gold so shining in the sun, that if it had spread a pair of wings and soared away, no one would have had occasion as I fancied, for the least surprise. But it stopped short of us in a very business-like manner when we reached the canal and, before we left the wharf, went panting up this hill again, with the passengers who had waited our arrival for the means of traversing the road by which we had come.

Work on the canal system in Pennsylvania was well under way by the year 1834, which saw the completion of the Main Line. This principal canal followed the Susquehanna and Juniata Rivers to Hollidaysburg (Fig. 7). Another went up the North Branch of the Susquehanna to Athens, yet another along the West Branch to Farrandsville. The Schuylkill Canal reached to Port Clinton, the Lehigh to Mauch Chunk and White Haven. Far to the east the Delaware and Hudson Canal was built to Honesdale. Up Swatara Creek a branch

FIG 10 DELAWARE WATER GAP
THIS VIEW IS SOUTHEAST FROM THE PENNSYLVANIA SIDE SCENICALLY THE MOST FAMOUS OF ALL THE PENNSYLVANIA GAPS, IT HAS PROVED OF LESS IMPORTANCE COMMERCIALLY BECAUSE IT DOES NOT GIVE DIRECT ACCESS TO THE ANTHRACITE COAL FIELDS

from the old Union Canal penetrated the mountains to Pine Grove All these canals followed the stream valleys In so doing they usually attained satisfactory gradients but were in constant danger from damage or ruination by floods

Curiously enough, no canal was built through the Delaware Water Gap, although this notch was early traversed by a wagon road, later by railroads The reason appears to be twofold, first that the Delaware River above the Gap makes a sharp turn northeastward away from the anthracite fields (Fig 7), and second that the country north of the Gap consists of ridges and plateau heights not given to agriculture Therefore, the two commonest reasons for canal-building in the east, coal and produce, were lacking as incentives for a canal through Delaware Water Gap The lower reaches of the river were paralleled by a canal, but this is foreign to the scope of this paper, since it passed through no gaps

On the other hand, the upper waters of the Delaware River saw the construction in the 1820's of the Delaware and Hudson Canal to bring coal out of the northern anthracite basin Before it was built coal lands had been surveyed by the Wurtz brothers about 1812 Their findings induced men to devise means of getting the novel fuel to market Options were taken in the Lackawanna Valley, and an outlet was provided through the Delaware and Hudson Canal along Lackawaxen and Wallenpaupack Creeks to the deep-cut valley of the Delaware, a distance of 16.5 miles Here, as on the main line of the Pennsylvania Canal over the Allegheny Front, there grew up a combination of railroad and canal From Carbondale to Honesdale an ancestral roller-coaster, the old "Gravity Road," took over where the grade was too steep for canal construction The cars carried the product of the mines down to Honesdale, there to be transferred to canal boats Abandoned today, only the remnants of the canal remain—a bit of towpath, a lock's crumbling masonry The tree-grown railroad grades mark the line of the gravity road of a hundred years ago It is indeed worth remembering that in connection with this very project the British-built locomotive, the *Stourbridge Lion*, was tried but was given up when the weak, wooden track was judged inadequate to support its weight. Today the ancient machine is commemorated by a monument at Honesdale

The Delaware and Hudson Canal was only one of several built into the anthracite fields Although, as remarked, some were not intended primarily for coal haulage, all eventually came to look upon such freight as their chief asset. The

FIG 11 ALONG THE LEHIGH CANAL

AT THE ENTRANCE TO THE LEHIGH WATER GAP THIS IS THE LAST REMAINING CANAL FUNCTIONING IN EASTERN PENNSYLVANIA THE SMALL CANAL BOATS TO THE LEFT HAUL "RIVER COAL" (DREDGED FROM THE BOTTOM OF THE STREAM) ALONG THE CANAL TO SUITABLE STORAGE PLACES. NOTE THE RAILROAD GRADES OF THE LEHIGH VALLEY (BELOW) AND THE LEHIGH AND NEW ENGLAND (ABOVE) ON THE OPPOSITE SHORE

Lehigh Canal was begun in 1827 As far back as 1792 the Lehigh Coal Mine Co had been organized to exploit the anthracite along the river beyond the Lehigh Water Gap The industry met no success until Josiah White and Erskine Hazard took over the project of making the Lehigh navigable A system using what were called "bear-trap gates" was adopted This consisted of V-shaped dams across the streams By such means artificial floods and high water could be created almost at will to carry the boats, coal-laden, down the river The greatest development followed the organization of the Lehigh Coal and Navigation Co in 1820 Canal construction began in 1825 Four years later the canal was opened A succession of slack-water stretches of river alternated with lengths of canal (Fig 13) Few passengers seem ever to have used the Lehigh Canal, but coal was for years sent down it in great quantities, 200,000 tons in 1837 alone It is noteworthy that today (1942) the Lehigh is the one remaining trans-gap canal that still operates, but only locally to carry coal dredgings from the river to shore for storage Like the Delaware and Hudson, the Lehigh Canal was connected with the mines by a gravity road The famous Switch Back at Mauch Chunk, after it had ceased to carry coal, was equipped with passenger cars and supplied a thrill to our immediate ancestors of pre-automobile days

Next in order westward is the Schuylkill Valley The Schuylkill Navigation Co operated a succession, partly canal, partly slack water with dams, to connect Philadelphia with the interior and eventually to tap the coalfields at Mount Carbon and Pottsville Its original purpose was not primarily for coal transportation, as the value of anthracite as fuel was still doubted Timber, agricultural products and other commodities were taken out over this line. In 1824,

four years after opening, the first coal boat to Philadelphia came down the Schuylkill Canal

Along Swatara Creek in Lebanon County a canal was finished in 1830 It was actually a branch of the Union Canal completed in 1827–28, which tied together the Schuylkill and Susquehanna Valleys by way of the Lebanon Valley south of Kittatinny Mountain. This route gave a navigable feeder to the southern anthracite field by way of Pine Grove The canal penetrated Kittatinny Mountain along the water gap of Swatara Creek and ended in a large reservoir a few miles above that feature Never of much importance, this canal was nearly ruined by a flood in Civil War times It never recovered from the blow

The most important of all our eastern canals, as may be judged, was the already mentioned Pennsylvania Canal itself, which followed the Susquehanna and its principal tributary, the Juniata This route was intended to connect Philadelphia with Pittsburgh From the principal line a shorter branch edged the east side of the main valley of the Susquehanna to Millersburg to tap the anthracite fields from their west side A branch canal and railroad tied it with the coal at Short Mountain Another canal ran up the west bank of the Susquehanna to a point opposite Northumberland at the confluence of the West and North Branches of the river Between the forks and the mouth of the Juniata several gaps were negotiated At the confluence the canal divided The branch to the east, known as the North Branch Canal, followed the North Branch of the Susquehanna and continued to the New York-Pennsylvania state line at Athens to connect with the Chemung and Chenango Canals of New York The canal up the West Branch followed the river to Lockport and Lock Haven and a little beyond (Farrandsville) to gain admittance to the soft coal workings in the Allegheny Plateau A branch swung southwestward from Lock Haven along Bald Eagle Creek Valley and through Milesburg Gap to Bellefonte. This line was operated by the Beech Creek and Bald Eagle Navigation Co

The Main Line, or Central Division, of the Pennsylvania Canal was the most important of all our artificial water routes, it included the Portage Railroad Passing through Harrisburg, the canal's course lay up the river to Duncans Island, whence it entered the valley of the Juniata In this lower part of its course it traversed three large water gaps in Kittatinny, Second and Peters Mountains The main line along the Juniata ran through Millerstown, Mexico, Mifflintown, Lewistown and Huntingdon to Hollidaysburg, where it connected with the Portage Railroad It had been the original plan of the builders to tunnel the Allegheny escarpment, but the idea was abandoned in favor of the railroad From the outset the canal had troubles Opposition from teamsters did not add to the happiness of its builders The main line had about twice as many locks as its rival, the Erie, and the Portage Railroad was a bottleneck For these reasons the Pennsylvania Canal was not the keen competitor of the Erie that its sponsors had hoped In fact, it is recorded that some Philadelphia merchants found it more economical and quicker to ship via the Erie than the Pennsylvania Canal. Necessity for speed was the downfall of this and many another canal The Portage Railroad was closed in 1857, and the decade 1850–60 saw the end in general of canal-building in the eastern United States The demise was synchronous with the railroad boom The following figures from Harlow[1] show something of the extent of canal-building.

[1] Harlow, A G, Old Towpaths, 1926, p 403.

	Miles
Columbia, Hollidaysburg, Johnstown, Pittsburgh	276
Susquehanna Div, Duncans Island-Northumberland	40
North Br Div, Northumberland-Wyalusing	124
West Br Div, Northumberland Farrandsville	75
Delaware Div, Bristol Easton	60
Beaver Div, Ohio River to Newcastle, plus	31

The day of the canals with their roistering romanticism soon passed At best they were deadly slow affairs, and the severity of Pennsylvania's winters and spring floods was enough to close them to operation for many weeks each year It is little wonder that the new spreading railroads gradually acquired much of the freight and passenger business Nevertheless, the canals did not immediately succumb Even after the turn of the century some feeble signs of life showed on several Today, except for the expiring gasps along the Lehigh, they are represented only by crumbling locks of caved-in stonework, weed-choked channels and the graceful curves of tree-grown embankments, still sweeping along many a valleyside Paradoxically, be it noted that the uncompleted Harrisburg and Hamburg Railroad met its fate when the Pennsylvania Canal fell into disfavor That railroad was planned as a feeder to carry produce from the back farms of Dauphin, Lebanon and Berks Counties out to the canal and the Susquehanna River The railroad never turned a wheel

As the old forts of French and Indian War days have left their stamp in place names, so too did the canals Several are suggestive of the time when towns sprang up along the routes of the man-made

FIG 12 SPRING FLOODS WERE A MENACE TO CANAL MAINTENANCE

DAMAGE DONE ALONG THE SUSQUEHANNA IN THE FLOOD OF 1936 DEBRIS AND RECEDING FLOOD WATERS ARE SHOWN ALONG THE ABANDONED CANAL NEAR DUNCANS ISLAND

waterways Among them are such names as Walnutport, Weissport, Port Clinton, Port Carbon, Port Trevorton, Beech Haven, Williamsport, Lock Haven and Lockport

Parallel Bands of Steel

Conflict early marked competition between the Chesapeake and Ohio Canal and the Baltimore and Ohio Railroad This friction characterized the growing war between canals and railroads It was to end in the extinction of the one and the survival of the other The canal no doubt had a certain advantage if not efficiency in handling nonperishable, bulky freight and goods that did not require speedy delivery The winter's coal could be hauled in the summer Nevertheless, canals were handicapped by the winter's freeze, and their slowness was their final nemesis Owing primarily to year-round operation and greater speed, if to no other cause, the railroads won out over the canals

If each year, from the 1830's on, one could have taken an aerial photograph of southeastern Pennsylvania, a comparison of these pictures would have shown railroad lines creeping westward and northwestward from Philadelphia Prominent was the Philadelphia and Columbia Railroad, which connected the city with the Susquehanna Valley by way of Lancaster From that place the Harrisburg Railroad chuffed north to the State Capital From Harrisburg additional lines invaded the mountains along the well-tried routes of the Susquehanna and Juniata valleys Almost from the start the picture has included the Pennsylvania Railroad advancing from Philadelphia to Pittsburgh Built to fight canals and railroads to the south and to the north, it followed the line of, and competed with, the Pennsylvania Canal, up the Juniata and down the Conemaugh The rails reached Lewistown in 1849, the foot of the Allegheny scarp in 1850. Communication over that feature was established two years later Although the Portage Railroad struggled to maintain itself, it soon gave up the ghost. With it passed one of the most picturesque and, for its time, most progressive features of our early transportation system

As with the canals, the railroads followed the lines of least resistance, the river valleys. They too made constant use of the gaps. Most of the Delaware Valley has been at one time or another used by railroads The Erie Railroad follows its gorge from Port Jervis northwestward. The Delaware Water Gap (Fig 1) has been traversed by two lines The now abandoned New York, Susquehanna and Western track hugged the New Jersey side, the Delaware, Lackawanna and Western uses the Pennsylvania shore After passing through the gap both roads used a smaller gap cut by Brodhead Creek through Godfrey Ridge Leaving the Stroudsburgs, the lines climbed the face of the Pocono Plateau, a feat strictly analogous physiographically to the problem met by the Pennsylvania Railroad in ascending the Allegheny Front along its spectacular Horseshoe Curve

Until the present decade the Lehigh and New England Railroad had a branch line through the Wind Gap (Fig 2) from northern Northampton County to Saylorsburg, north of the Kittatinny Mountain. The line is gone, but special mention is made of it because in this specific instance use was made by a railroad not of a water gap but of a wind gap, *the* Wind Gap, in fact Continuing west, the next important use of the gaps by rail lines is at the Lehigh Today the Central Railroad of New Jersey, the Lehigh Valley Railroad and the Lehigh and New England Railroad all pass through Kittatinny Mountain at the water gap of the Lehigh River (Fig 11) Additional use is made of gaps along this

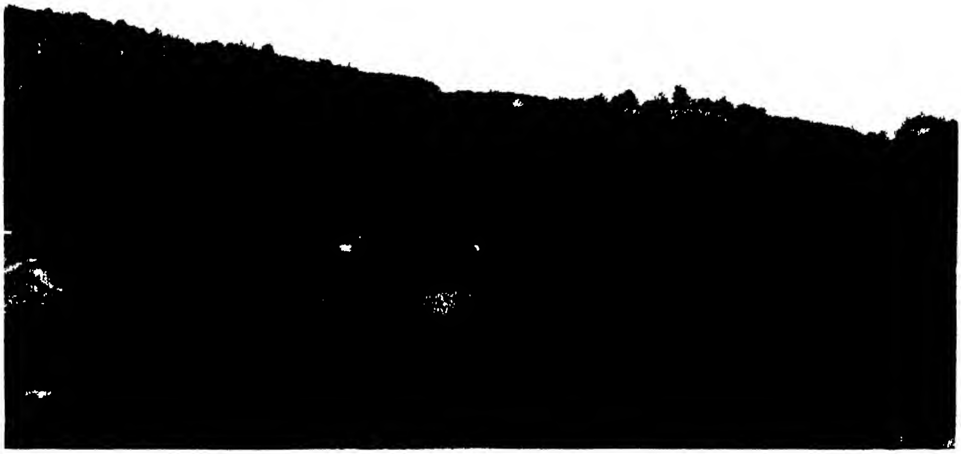


FIG 13 RAILROADS GRADUALLY DROVE THE CANALS OUT OF BUSINESS

VIEW ALONG THE LEHIGH TRACKS OF THE CENTRAL RAILROAD OF NEW JERSEY PARALLEL LOCK AND PART OF THE LEHIGH CANAL AT THIS POINT A DAM CREATES THE SLACK WATER IN THE BACKGROUND THE LOCK SERVES TO LIFT THE BOATS OVER THE DAM THIS FRAGMENT OF CANAL IS STILL USED IN HANDLING "RIVER COAL"

FIG 14 A RIBBON OF CONCRETE

ROADS LIKE THIS ONE CARRY THE AUTOMOBILE TRAFFIC OF TO-DAY THROUGH THE GAPS VIEW ALONG U. S ROUTE 309 ON THE WEST SIDE OF THE LEHIGH RIVER LEADING TO THE LEHIGH WATER GAP, WHICH IS LOCATED NORTH OF ALLENTOWN, PENNSYLVANIA.

river by the first and second of these railroads as they continue north through the ridges south of Mauch Chunk and beyond, into and across the anthracite fields.

Along the Schuylkill, railroads appeared early, for it was by this route that coal could be readily hauled to Philadelphia and tide water. The Reading Railroad (at that time, of course, the Philadelphia and Reading) ran a branch line from Reading to Pottsville. Not to be outdone, the Pennsylvania Railroad did likewise. Today both lines use the gap along the Schuylkill in negotiating the passage of Kittatinny Mountain into Carbon County. The Reading also maintains a line along Swatara Creek, employing the water gap on that stream through Kittatinny Mountain in northern Lebanon County. It is not necessary here to discuss numerous uses of gaps and stream valleys throughout the anthracite fields. In general, this region of highly folded rocks has yielded, through erosion, many parallel or converging ridges. Gaps a-plenty slash the mountains and have been of the utmost value in exporting coal from the area.

The Susquehanna Valley and its tributaries, particularly the Juniata, have from the beginning furnished important routes. We cited the advance of the Pennsylvania Railroad along this course. Let us examine its progress more particularly. Both the Pennsylvania and the old Northern Central railroads traversed gaps in Kittatinny, Little, Second and Peters Mountains north of Harrisburg. The Northern Central, now incorporated in the Pennsylvania System, then took the main valley from the confluence with the Juniata and pushed northward. A few gaps were encountered below Sunbury. There the Susquehanna, Bloomsburg and Berwick was built to enter the anthracite fields "from the back door." Tracks of the Pennsylvania System follow the West Branch of the Susquehanna into the northwestern corner of the state. In this it achieves what the canals failed to do. It avoids the difficult ascent of the Allegheny Plateau by using the entrenched river channel above Lock Haven. Coming down from the north to connect with the Pennsylvania near Lock Haven is a branch of the New York Central, noteworthy since it follows Pine Creek gorge in crossing the plateau. A passing mention may also be made of the utilization of the North Branch of the Susquehanna by the Lehigh Valley Railroad into New York State and of the fact that the Delaware and Hudson and the New York, Ontario and Western Railroads have access to the northern anthracite field by gaps in its northern mountain rim. Somewhat analogous to this is the situation encountered to the southwest about the Broad Top coal field in Huntingdon and Bedford Counties, where the Huntingdon and Broad Top Mountain from the west and the East Broad Top (narrow gauge) railroads enter this isolated area through gaps. In the case of the second line, tunneling is also used.

Where there were no gaps the railroads experienced difficulties. Notable in this regard is the Baltimore and Ohio. Between Cumberland and Wheeling eleven tunnels were drilled for this line. During the building of the Kingwood Tunnel, which occupied a full year, the cars were hauled over the mountain along a temporary, zigzag track. Perhaps because of the successful example set by the Baltimore and Ohio, it was proposed as early as 1840 to run a line across southern Pennsylvania from Philadelphia to Pittsburgh. Such a route would have required extensive tunnel construction. The original scheme was abandoned but was revived a generation or more later in the charter of the South Penn Railroad. A number of tunnels were actually started and much grading was completed before the line was abandoned. The unfinished road

was to have pierced a series of gapless mountains by way of Franklin, Fulton, Bedford and Somerset counties Its route has recently suffered a belated reincarnation in that the old roadbed and unfinished tunnels have been taken over and to a large measure developed into the Pennsylvania Turnpike

So, the railroads came to the gaps East of the Susquehanna Valley their principal incentive was anthracite Around it grew up that well-known group of camel-back-locomotive-using "hard coal roads" These included most of those mentioned In the appropriation of the gaps the railroads went a step farther than the canals were able to do Because of hill-climbing ability, rail lines overcame previously prohibitive grades Where canals might come near to the mines, they were invariably dependent upon railroads or tramways of some sort from mine to boat Contrasted to this, the railroads can load at the mines, then haul the coal through to its destination without suffering loss of time to reload To this is added a year-round schedule impossible for the canal boat

Electric street cars have nearly vanished from the interurban landscape The days when we toured the country on "trolley rides" ended with the widespread use of the automobile But while the trolley car was still at its best, lines occupied two of our major water gaps The Stroudsburg, Water Gap and Portland Railway rattled along the highway on the Pennsylvania side of Delaware Water Gap This line was obliged to zigzag over Godfrey Ridge south of Stroudsburg The railroads had taken up all available space along Brodhead Creek Compared with the steam locomotive, however, the trolley was as much better a hill climber as the steam line had advanced over the canal The other gap used by an electric line was the Susquehanna The Valley Railways Company operated along the west side of the Susquehanna from a point opposite Harrisburg to Marysville This line was abandoned recently in favor of busses

FIG. 15 HIGHWAYS ARE GREAT LEVELERS

IN THIS PICTURE STATE HIGHWAY 903 CLIMBS THE SOUTHWESTERN SCARP OF THE POCONO PLATEAU.

Gasoline and Concrete

The automobile far outdoes the railroad as a leveler of grades, even as the electric trolley was ahead of the steam line or the latter outdistanced the canal Today a network of concrete and other hard-surfaced state and county roads crosses and recrosses our mountains. Yet, despite the apparent annihilation of all but the heaviest grades, many a highway still follows the long-established travel habits of its predecessors. They too use the gaps as the best means of reaching beyond the mountains The following tabulation shows which gaps in Kittatinny Mountain alone are penetrated by present-day highways in Pennsylvania.

Gap	*Highway number*
Delaware Water Gap	U S 611
Wind Gap	Pa 12, 115
Lehigh Water Gap	U S 309
Schuylkill Water Gap	U S. 122
Swatara Water Gap	Pa. 72
Indiantown Water Gap	Pa 443
Manada Water Gap	Pa. 894
Susquehanna Water Gap	U S 11, 14, 22 Pa 14
Sterretts (wind) Gap	Pa 34
Doubling (wind) Gap	Pa. 233

Besides these routes there are others that disregard the gaps altogether or take advantage of mere low places in the crests. Notable examples along Kittatinny Mountain are Route 29, north from Lehigh County, Route 83, between Berks and Schuylkill Counties; and Route 274, southwestward from western Perry County To cite other examples of highway use or nonuse of the gaps throughout Pennsylvania would take pages of detail Merely, as a final remark, contrast the low-grade course of U S Route 22 (the old canal and rail route) up the Susquehanna and Juniata Valleys with that of U.S Route 322 over the Seven Mountains Yet, before leaving this topic, remember once more the construction of the Pennsylvania Turnpike Remember that it developed the unfinished grade and tunnels of the defunct South Penn Railroad It is significant as an example of low-grade, modern highway construction, which has refused to make use of the natural openings through the mountains for its course but boldly burrows through the ridges in a succession of seven tunnels Our highways are arteries along which pleasure and commercial vehicles scurry Use a "scenic route" across mountain ranges or plateau country of the central counties Then turn east to the anthracite region The busy line of coal trucks whirling back and forth is reminiscent of days when first the canal and then the railroad had "all the gravy" in this business Already such roads used by passenger bus and van or truck are a serious menace to railroad revenue

Wings over the Mountains

The highways indicate a partial emancipation of travel from mountain barriers One might expect that air lines would be totally liberated from the influence of topographic features Actually they are, yet did you ever notice, while driving along one of our major concrete highways that follows a river and cuts through gaps, huge figures sprawled across the pavement? They are route numbers, but obviously not put there for the information of the whizzing motorist They serve as guides to the plane pilot. Even wingéd man tends roughly to follow the warpath of the pre-Columbian savage

Further Military Aspects

The gaps influenced the savage in his migrations and raids They figured in the French and Indian and in the Revolutionary Wars. They came back into the picture during the Civil War, indirectly, because such gap-using railroads as the Baltimore and Ohio and the Pennsylvania Railroad were important mili-

tary factors The Civil War was the first major conflict in which railroads figured largely in the movement of troops and supplies Occasionally the armies fought over these new and important military adjuncts Yet, there were other more direct applications of the topographic features to the war than their use by railroad lines What American school boy has not tingled as he read of the cavalry raids up and down the Shenandoah Valley? Bold horsemen invaded southern Pennsylvania, descending through gaps in more than one swift foray How many are aware of the part that topography played in the Gettysburg campaign? Not the actual battlefield itself is meant The geology and physiographic features of that area and their influence on the tide and outcome of the battle have been expounded Notice, instead, certain other factors immediately preceding the decisive battle of the war

General Lee's army was moving north in June of 1863 One of its immediate objectives in Pennsylvania was to take Harrisburg, important for two chief reasons In those days, prior to the erection of the dam at the city, the broad but shallow Susquehanna was fordable during summer's low water This meant a ready crossing Harrisburg even in those days was a rail center Trains pulled out to all four cardinal points Control of Harrisburg meant a potential opening to strike Philadelphia, Baltimore and Washington from the west and north Control of Harrisburg meant cutting the Pennsylvania Railroad at a vital point where it entered the mountains through a gap that could not be by-passed Needless to say, the attempt was unsuccessful because of the advance of the Union troops from the east and southeast Finally, regarding the Gettysburg campaign, on the eve of the battle a scouting or advance party of Confederates approached Sterretts Gap ten or twelve miles west of Harrisburg with the intent of taking this commanding position However, finding that it was held by a strong force of Union men, the Southerners prudently withdrew. This wind gap, not Bloody Angle of Pickett's Charge at Gettysburg, is truly "the high-water mark of the Confederacy," if by that expression we mean

FIG 16 A HIGHWAY THROUGH PENNSYLVANIA MOUNTAINS
OVER THE MOUNTAINS, RISING FROM THE GAPS IN THE DISTANCE, THIS HIGHWAY CROSSES THE RIDGE FROM WHICH THE PHOTOGRAPH WAS TAKEN.

the most northern point attained by an armed body of its troops. For the last time in history, one of our gaps figured in war

Geology through physiography and topography has influenced the development of our transportation system. It has been a factor in several wars. The rate of settlement was at first retarded by the mountains, then speeded by the use of water and wind gaps through those mountains Travel routes have been affected from the earliest trails to the latest of modern devices for moving man and his goods.

In these days of uncertainty, with possible invasion by armed forces, attacks by land, by sea and from the air of our eastern shores, one is tempted to speculate upon possible future situations Nay, such have even been anticipated, for it was partly with its military use in mind that the Pennsylvania Turnpike was constructed Here a low-grade, hard-surfaced route is provided from the interior to the seaboard Numerous exposed bridges and danger of damage from floods along other roads are obviated Very real are such menaces along the old Susequehanna-Juniata Route (Fig 12) By this new route, mechanized troops and supply trains can move across (actually, *through*) the mountains with speed and with a reasonable assurance of their safe arrival

The lowland fringe of Europe has throughout history provided a relatively easy line of march for armies from Russia all the way around to the Pyrenees Mountains At no point along this coast is an elevation in excess of, let us say, 200 meters encountered A similar situation is present on our own coast below southern New England But there the analogy ends Mountains form no backdrop barrier separating coastal Europe from the interior North America has this feature Lateral movements north and south may not be hampered by heights of land Movements westward are definitely hindered if not stopped Given a sufficient force that is properly equipped to hold the gaps, our Appalachian Mountains still present a definite deterrent to an invading enemy Yet who can say today what barrier will stand in staying military movements of an enemy with air superiority?

AGRICULTURE AND THE NATIONAL EMERGENCY*

By Dr. FIRMAN E. BEAR

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When the Pilgrim Fathers landed at Plymouth, Massachusetts, in December, 1620, the 1900 million acres of land now constituting the United States of America was inhabited by some 800,000 Indians whose braves hunted, fished, and fought, while their squaws did the farming. Although the women grew corn and beans and stored the surplus for winter use, the redskins depended largely upon wild game, nuts and fruits for their food supply Under their system of land use, each person had some 2400 acres at his disposal Whether that large an acreage was required for his support, however, or whether population growth was limited by some other factor, is not known with certainty.

When, on another memorable December day 321 years later, Japan undertook to wrest some of our outlying possessions from us, a well-fed, complacent population of 133 million people, 170 times that of the original Indian tribes, was startled into action. For between Plymouth Rock and Pearl Harbor, agriculture, by the aid of industry, had so developed the land resources of this country that one acre was doing the work of more than 200 acres left to Nature, and doing it much more dependably. Now, with only fourteen acres of land per person,[1] our many millions are not only abundantly fed and clothed, but large surpluses of grain, meat and fiber are available for export.

Except for periods of war, the most difficult problem American farmers have ever faced has not been that of growing enough food and fiber to meet the needs of this Nation, but rather of finding an outlet for that portion of their produce for which we can find no economic use. The hunger that the Indians must have known and that many millions of Europeans and Asiatics are now enduring is entirely foreign to the experience of this proud land of plenty Such food scarcity as certain groups of our people have suffered from time to time has been largely due to their very low earning power rather than to exorbitant costs of the products of the soil [2]

It is apparent that agriculture involves something more than the mere acceptance and collection of the products of Nature. It consists in harnessing Nature to human needs. Sir John Lawes once defined it as "the artificial accumulation of certain constituents to be employed either as food for men or animals upon a space of ground incapable of supporting them in its natural state" The potentialities of food and fiber production in the United States, if the land as it now exists could be brought to its maximum agricultural productiveness, are enormously greater than most people realize.

The growing of more than adequate supplies of foodstuffs for our present population is normally so readily accomplished that it is almost unthinkable to us that anyone, any place in the world, should ever go to bed hungry. Like the

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[1] The density of the population of the United States is only about one-eighth that of Germany.

[2] Some 30 million of our people are ill fed, as measured by modern nutritional standards.

Goddess of Liberty adorning its ocean door, the United States of America extends a helping hand, overflowing with the choicest foods, to the starving peoples of all the earth. Even in this period of war, as ever greater demands are being made upon our granaries, the problem is not one of any lack of capacity of the land to produce more and more grain with which to refill them, but of a shortage of labor to harvest the grain, and a dearth of facilities with which to effect its world-wide distribution.

Yet in times like these one can not help wondering whether this war-time draining of our soil resources will not have to be paid for in the coin of a much greater expenditure of effort that, after the conflict is over, may be required to extract our living from the land. The question is: Has the Malthusian principle been permanently set aside, or will it return to plague even us when our war-impoverished population presses forward with an ever-increasing appetite for the products which the exhausted land no longer so readily supplies?[3]

It must be apparent, even to the city man whose only contact with the land is by way of the things he eats, that our soil has already lost much of its virgin fertility and that a larger and larger percentage of the elements now being removed from it by crops will have to be returned. In proportion as more of the farmer's after-the-war dollar must be reserved for the purchase of soil restoratives, less of it will be available for the buying of health, education, travel, conveniences, and the other refinements of modern life. The privilege of enjoying these semi-luxuries is what has distinguished the American farmer from the European peasant. Our larger farmers are lords in their own right, and a great many sons of American soil rise to positions of high attainment in industry, education and government. In contrast, the peasants of Europe are tied to the land, one generation after another, bearing an undue portion of the burdens of mankind upon their backs.

War, while it lasts, means wealth to farmers, for with war comes increased demand and higher prices for the things they have to sell. Although limits are placed upon selling prices of certain farm products, these limits are set sufficiently high to stimulate greatly increased production of those crops for which there is greatest need, an abundance of the necessary foods being the first essential in winning the war. It is to be expected, therefore, that farmers, whether moved by patriotic or mercenary motives, will do their utmost to make every acre count. But, in so doing, they are quite likely to neglect the care of the soil. That was our experience during the first World War and a very high price was subsequently paid for the very prodigal use to which the land had been put. Among the more spectacular consequences of this orgy of expansion of cropping acreages[4] across previously unbroken western sods was the development of an enormous Dust Bowl which spread like a cancer and was almost as difficult to bring under control. Many million acres of marginal land may again be brought under the plow if this war lasts several years longer. The rapid rise in the acreages of soybeans, peanuts, and flax, growing out of the necessity of producing oil to replace that normally imported from the Orient and the South Seas, shows one direction in which our farmers are now being encouraged to expand.[5]

[3] Some population specialists are of the opinion that our population curve may reach a peak at around 160 million.

[4] The area devoted to harvested crops was increased by some 40 million acres during the first World War.

[5] Increased acreages of any crop for which there is special need are obtained by guaranteeing minimum prices and by allotting more fertilizer, machinery, and labor to the farmers producing it.

When the American Continent was an Indian Paradise, its soil was securely sewed to the earth by the roots of grasses and trees that formed a cover over the whole continent. But once the white man stepped ashore and pointed his plow westward, the threads were broken and the soil, joining hands with the rain, began sliding down the slopes and rushing on out with the river waters into the sea. To make matters worse, the crops which the Indians cultivated and the pioneers quickly adopted are of such nature that, by growing larger and larger acreages of them, we have developed the most destructive type of agriculture the world has ever known

Strange as it may now seem, the corn, tobacco, potatoes, beans, peanuts, pumpkins, and tomatoes which cover many millions of acres of land in this country were entirely unknown to the Old World before the discovery of America by the Admiral of the Ocean Sea Our European ancestors on whom we had to draw for our knowledge of what to do with the land and when to do it had had no experience whatever with any of these crops, and only second-hand knowledge of the semi-tropical cotton crop, the popularity of which grew so rapidly in our warmer states that it soon became firmly entrenched as the "Queen of the South." The peculiar fact about all these plants is that not only must the land be plowed in preparation for them, but it must be kept free of weeds all summer long until they mature Nearly 140 million acres of our finest farm land were being turned with the plowshare and planted to these clean-cultivated row crops, year after year, before anyone realized what disastrous effects their production was having on the staying powers of the soil.

When the situation became so appalling that even the blindest among us could see the handwriting of erosion on the sides of the slopes, far-reaching steps were taken by the federal government to bring our enormous soil losses under control. But already some 50 million acres of land had been permanently ruined for cropping purposes. And although our hastily devised methods of erosion control have been fairly effective,[6] the fact remains that our agricultural economy still needs to be redesigned around crops that are less destructive to the soil than are those which we inherited from the Indians Now another war, by far the most devastating of all history, is upon us and the prospect of our ruining still more land again looms like a storm-cloud on the horizon.

What makes this problem so difficult to deal with is that our farmers, having been made machinery-minded by alert American engineers, have taken to power farming like the proverbial duck to water Of all the devices which these inventive geniuses have perfected, none compares with the farm tractor in its power for evil, or good, depending upon how it is used. No sooner had the up-and-coming farmer's son laid his eyes on the tractor than he began the not-too-difficult task of inveigling his father into buying one. As a result, the number of tractors sold for farm use increased so rapidly that the 2000 manufactured in 1909 grew to 200,000 more efficient ones in 1920, and to a total of nearly two million fast-moving types in operation in the United States by the end of 1942.

Four highly important developments followed rapidly in the wake of the growing use of power machinery on American farms The horse and mule population fell from 25 million in 1920 to 4 million twenty years later; some 50 million acres of land that had been tied to the earth by the root systems of the hay and pasture crops required to feed these work animals were released to the plow; thousands of miles of fences, which had had the effect of serving as Maginot lines

[6] A great deal of attention is now being given to the development of cropping and soil-management systems that do away with the necessity of frequent plowing of the land

against soil erosion, were plowed up to make much longer fields for the convenience of the tractor; and the percentage of the people required to produce the necessary supplies of food for human and animal consumption was greatly reduced, the farm population remaining more or less stationary between 30 and 32 million, while the total population was growing from 105 to 135 million

Whatever effects the present war may have on the economy of this country, it is difficult to conceive of any retreat of the successful farmer from his present position as an engineer sitting at the wheel of a mighty motor that races and roars across the fields, pushing down more fences, tearing up more sod, and cultivating more crops, day and night,[7] as long as more land is available. And it seems probable that, after the war is over, the young farm folks will still insist on using their usual allotment of motor power to speed to the distant city to see the same shows, dance to the same music, and sit at the same tables as the rest of the world In fact, the war will tend to greatly further the interest of the farmer's sons in motorized equipment. Certainly, as soon as the last air battle has been won, the aviation-minded veteran will immediately set to work leveling off a landing field in preparation for the airplane that will be added to the long line of high-powered machinery on the old home place Compared with the experience of those of us who were barefoot boys on the farm some 50 years ago, the farming of tomorrow can be made a glorious adventure in which one enjoys the luxury of independence without the drabness and drudgery that were once all too much a part of life on the land

But as one studies the picture further he begins to be disturbed about the cost of equipping the modern farm with its many machines, and about the assembling of the larger acreages of land which must be acquired to keep this expensive equipment busy enough days of the year to make it pay its way Profitable power farming means many more acres under one management and much higher intensity of farming. The great mass of farmers possess neither the funds to finance such a farming enterprise nor the skill to manage it, yet they will have to compete with those who have the capacity to make big business out of the growing of plants and animals[8]

It seems important to point out that there are just as capable men in control of our better agricultural enterprises as manage our better organized manufacturing plants The men who operate large farms successfully must possess the combined qualities of the artizan, the production engineer, the salesman and the executive They must be able to adjust their operations to the vagaries of the weather. And they must know how to deal with living things that are subject to disease and death, in contrast with the relatively simple problem facing the manufacture of inanimate objects in a factory.

If one contents himself with an examination of the statistics of total production of the more important farm crops in the United States as a means of estimating whether or not all is well on the land, he finds little reason for alarm. Thus, the yearly production of corn since 1920 has been between 2½ and 3 billion bushels; of wheat, between 600 and 900 million bushels; of potatoes, between 300 and 400 million bushels; and of cotton, between 10 and 18 million bales, the fluctuations in production being determined largely by the weather and the anticipated selling price. Al-

[7] It is a highly significant fact that tractors are now equipped with headlights and are often operated all night long during the busier portions of the crop season.

[8] In many cases tenant farmers have been crowded off the land by the expanded operations of farmer-owners who, with their sons' help, are able to operate large tracts of land with a high degree of efficiency by the use of tractors.

though careful analysis shows that there was a steady decline in acre yields in the Corn, Wheat, and Cotton Belts from 1905 forward, reaching an alarmingly low level in the drouth years of 1934 and 1935, acre yields since that date have risen to new high levels of which those of the year 1942 were, very fortunately, the highest this country has ever known.

There is some doubt, however, whether these currently higher yields indicate definite upward trends from better land management or are mostly the result of more favorable seasons If one considers the very marked improvements that have been made in agricultural machinery, the much better varieties of crops that are being grown; the much larger amounts of lime and fertilizer that are being used, the greatly improved technique that is being employed in the control of diseases and insects; and the great strides that have been taken in erosion control he wonders why yields have not risen to much higher levels than the records show. For notwithstanding all that science has done to aid the farmer, the average acre yields in the United States are only 25 to 30 bushels of corn, 13 to 15 bushels of wheat; 100 to 120 bushels of potatoes; and 160 to 200 pounds of lint cotton Every farm scientist knows that twice those averages can readily be produced It is particularly distressing to note that the great State of Georgia, growing some 3½ million acres of corn, produces an average yield of only a little over 10 bushels of grain per acre[9] In contrast, a capable farm boy in the neighboring State of North Carolina once grew 232 bushels of corn on one measured acre of land

[9] The South is suffering the consequences of a lack of diversification of their agriculture, too large a percentage of the land being devoted to cotton and corn and too small an acreage to the small grain, hay, and pasture crops. Much of the land is bare of any type of cover crop during the winter months.

One of the most spectacular developments in agricultural production in the United States within recent years has been that arising from the breeding of hybrid corn as a result of which acre yields of this crop have been increased by an estimated fifteen per cent over what they would have been with ordinary corn varieties Yet plant breeding and selection, as applied to this crop, have been designed to take greater advantage of soil resources rather than to economize in the elements of fertility. Thus the yields of hybrid corn are higher than those of the ordinary strains because the roots of the hybrids are able to extract more nutrients from the soil. This means that the negative effects of indifferent soil-management practices are being compensated for by the positive effects of growing strains of plants that rob the soil more efficiently.

Developments in plant breeding must be associated with improvements in the technique of land management for continued success This involves the withdrawal of highly erosive areas from cultivation; farming on the contour the parts that are plowed; employing cropping systems that reduce the necessity for plowing; conserving farm wastes and returning them to the land; and greatly increasing the consumption of lime and fertilizers.

In times of war, and of agricultural prosperity, some of these improved practices are put into effect on a large scale, but others are set aside as being more applicable to times of peace. Thus, the average grain farmer will endeavor to apply more lime and fertilizer during the war, but he will also plow more land and pay less attention to the control of erosion. Our hope lies in the possibility that the need for careful attention to our land resources was so forcibly brought to the attention of the people of this Nation as a result of the soil debacle of the last war that federal conservation agencies

will be permitted to function with ever-increasing effectiveness throughout the present conflict and afterwards.

There are many disturbing facts which will have to be kept in mind in dealing with the combined problems of soil conservation and land use in the United States as the years grow into centuries. Among these are the serious consequences of the alternating periods of agricultural prosperity and depression that are associated with wars;[10] the high percentage of tenant farmers of uncertain land tenure, the constant loss of resourceful farm boys and girls to the city, and the fact that the average small farmer is more and more poorly prepared to meet the competition of the well-financed and capable big-business type of individual operating a large and highly mechanized farming enterprise [11]

What happens to the small farmer and the land he farms is a matter of considerable moment to all of us. And our interest is more than that involved in merely being assured that there will be plenty of low-priced food with which to fill this generation's stomach. It will be recalled that Oliver Goldsmith once voiced his concern with this subject when he wrote: "Princes and lords may flourish or may fade, a breath can make them as a breath has made, but a bold peasantry—the country's pride, when once destroyed can never be supplied" But Goldsmith had been born of an economic system of which peasantry was an integral part It would never have occurred to him that peasantry, in itself, was a sign of national decadence

The chief objective of farming, to the average farmer, is not that of accumulating wealth. In fact, there are very few wealthy farmers in the sense in which that term is normally used. Farming is a way of living. But it must be a way of living *well* if it is to play its part in the growing, developing, and educating of its share of the Nation's youth [12] There is no location that is comparable to a prosperous farm as a place to be born. Yet in proportion as the small farmers are reduced to poverty and peasantry, too many farm youths will crowd into the industrial centers to their own disadvantage, and to the detriment of the Nation as a whole.

It is highly important that thoughtful men of both town and country stop to consider the net effects of war and its by-products on the peaceful pursuits of those who till the soil. The small farmer is no more inefficient than the small business man He plays a useful part in the national economy His costs of production may be higher than they should be but his contribution is more than mere farm produce He represents a great stabilizing influence on the thinking of the Nation And those of his sons who rise above the land to positions of great influence in the affairs of men carry their country philosophy into the councils of industry and government

To avoid poverty and peasantry, some means must be provided for making the economic position of the small farmer more secure [13] This may call for much more decentralization of industry which still, for no very good reason as of this day, tends to be huddled about the large cities. The more recent tendencies of some of the larger manufacturers to break up their production into smaller units and scatter them about the country needs legislative encouragement.[14] For such distribution not only permits of

[10] Prices of farm products fall sooner, and farther, and tend to stay down longer after the war is over than do those of other commodities

[11] About one-third of our farmers consume as much or more than they produce and make little or no contribution to the Nation's food supply.

[12] Farm families constitute about one-fourth of the Nation's population but they supply about one-third of the Nation's youth.

[13] Some 3 million of our farm families are now living at distressingly low peasant-like standards.

[14] Some 25 million people classed as rural live in the country but are employed in the city.

bringing those city folks who desire it out into the country, but permits the farmer and his sons and daughters to add to their income by spending a portion of their time in the factory without leaving home. When depression again comes, as it most assuredly will, such farm folks can weather the storm much more securely than would have been possible had they been turned loose on city streets.

But our thoughts about farmers can not be divorced from our thinking of the soil of which they are the guardians A nation's security is no greater than the fertility of its soil So far, land owners, large or small, still assume that it is their privilege to do whatever they wish with the soil, and the law agrees as long as they do nothing to injure their neighbors But if we carry our thinking farther we come to the realization that it is also important that the land owner do no damage to the man who follows him in the ownership or tenantry of the land, whether that man be his son, his neighbor's son, or the son of someone still farther removed from the immediate locality In due time we shall have to decide whether our farmers can be induced to care for their own and the nation's land by some system of subsidies that may be applied to the erodible areas, or whether they must be required to do it through some form of compulsory legislation.

In a democratic system of government such a problem normally resolves itself into the setting up, by legislative action, of a system of procedure whereby farmers can organize themselves into districts in which the best interests of all are permitted to set aside the unrestricted freedom of the few who fail to appreciate their obligation to that portion of the soil which, for their lifetime, happens to have been intrusted to their care But there are large areas of land of low potentialities for crop production whose owners must be subsidized by the government, or the ownership must be transfered to the township, county, state, or nation. Such land has value for purposes that may be much more important than if it were used for the growing of corn, wheat, or cotton. For example, there is great need for the development of vast forest, recreational, and game preserves, in which a large amount of healthful, open-air work is involved. The farm folks of these areas who otherwise would have lived in penury may become partners in such a program to the advantage both of themselves and of the communities in which they live.

But philosophical considerations regarding agriculture must be ruthlessly shoved aside for the moment in order that we may concentrate our attention on the immediate problem of defending the freedoms for which we stand Reduced to its bald necessities, our job is not only to win the war, but of seeing to it that our enemies produce a great deal less, and this applies to food as much as it does to munitions. For in the final analysis our enemies will lose the war because of the lack of food.

The currently spectacular military campaign in North Africa was undoubtedly undertaken for the purpose of establishing a base from which southern Europe could more readily be reached by air and sea. But when it succeeds it will have had the further highly important effect of not only shutting off large supplies of grain, meat, and potatoes but of phosphate rock as well. Previous to the present World War millions of tons of mineral phosphates were imported into Central Europe from Africa, America, and Russia every year. These phosphates, when transformed into superphosphates by the use of sulfuric acid, played a crucial part in crop production Soon the only remaining sources of phosphate for the areas that are ringed by steel will be the basic slag, obtained in the refining of iron ores, and the bones of slaughtered animals,

and these will be far from adequate to meet their needs.

Some idea of the importance that has long been attached to the use of phosphatic fertilizers in Germany can be obtained from a quotation taken from the writings of Baron von Liebig, a world-famous German chemist of a century ago: "England," said he, "is robbing all the other countries of the condition of their fertility. Already in her eagerness for bones she has turned up the battlefields of Leipsig, of Waterloo, and of the Crimea; already from the catacombs of Sicily she has carried away the skeletons of many successive generations. Annually she removes from the shores of other countries to her own the fertilizer equivalent of three and one-half million men whom she takes from us the means of supporting and squanders down her sewers into the sea. Like a vampire she hangs upon the neck of Europe—nay of the entire world—and sucks the heartblood from nations without a thought of justice toward them, without a shadow of lasting advantage to herself."[15]

Germany is now in possession of the world's largest known supplies of fertilizer potash. She has developed the finest factories the world has ever known for pulling nitrogen from the air and putting it at the disposal both of her agriculture and of her army. But she has not been able to solve her phosphate problem. The hunger of the soils of the German-dominated nations for phosphates can no longer be satisfied and the result will be that crop yields will continue to diminish until this need can again be met. That will have to wait until the war is won.

Many millions of men, women, and children in Central Europe are now losing their lives not by being struck down by bullets but from the diseases that are associated with a lack of proper food. Unfortunately, we must add to their distress by making full use of all the means of withholding food, and the agents for its production, at our disposal. Yet, as soon as our armies have started their march to Berlin we must be prepared to supply food for all of the freed peoples as rapidly as they are released from enslavement. This is a truly gigantic task, both as to production and transportation, under conditions of war.

If the war continues for several years, it will be necessary to ration not only sugar, coffee, meat and milk in the United States, but most of the other articles we eat and wear as well. We would do well to give immediate attention to the question as to exactly how our manpower is to be distributed among the army, industry, commerce, and agriculture. Farmers are already short of labor, they are virtually unable to purchase new equipment, and they will soon be seriously handicapped for lack of rubber. Furthermore, the men who remain on the land will be getting older and less agile every year. And it must be kept in mind that there is no guarantee that the widespread good weather of 1942 will be repeated in 1943 and 1944.

Yet, whatever the handicaps and uncertainties, our farmers must not only feed ourselves, large numbers of our allies, and many millions of those who will be liberated from the Axis yoke, but they must build up a surplus to take care of the pressing after-the-war needs of many impoverished peoples that can not wait until another crop season has gone by. The more quickly we and our South American neighbors can make amends for the distress occasioned by the war and get the people of the devastated countries back to a semblance of normal living, the greater our likelihood of being able to avoid moral disaster, for the suspicions and hates that are lighted by

[15] Much of the present German philosophy of war has arisen from the resentment that has grown up as a result of the repetition of these and similar concepts.

wars are fanned into intense flame by hunger, pestilence, and poverty[16]

But one important aftermath of the war which we can not ignore will be the much greater concern of all peoples for the necessities of life As soon as the terms of peace have been signed the nations that rise up out of the ruins will immediately take thought of their land and the things that can be made to grow on it. Before many years have passed food surpluses rather than scarcities will again have developed. American farmers will once more be put through an economic wringer that may squeeze out more profit than was absorbed from the relatively high selling prices that now prevail

Many maladjustments in agriculture will arise out of the expanded production of certain crops required for war use. The bottom will quickly drop out of the market for some of the war crops while the demand for others may grow because of new peace-time uses to which the latter may have been found adapted. War-made improvements in industrial processes may relegate some before-the-war crops to positions of much less prominence. Wood pulp, for example, may become a more active competitor with cotton, forcing the southern farmer into greater diversification to the detriment of the corn and hog men of Illinois and Iowa, and the dairy farmers of Wisconsin and New York.[17] On the other hand, corn, small grain, sugar beet, and potato surpluses may find an outlet in alcohol for use in the farm tractor, auto, airplane. It has been estimated, for example, that about 2 of Iowa's 10 million acres of corn would be required to feed the farm motors of that state.

But when the life-and-death scramble for a place under the agricultural sun again gets under way, many farmers will go down to defeat for no other reason than that of having a war-depleted soil. Yet the loss of fertility occasioned by the exportation of agricultural products, no matter how troublesome it may be, does not present a problem so insolvable as one might think, even though millions of tons of nitrogen, phosphorus, potassium, calcium, and other elements will thereby have been siphoned out of the soil and shipped abroad. By the time the war is over the capacity of the air-nitrogen plants in this country will have been enormously increased and when this nitrogen is no longer needed for explosives it can be put to work in crop production. Fortunately also, the United States has the earth's richest phosphate deposits, our known supplies of this precious rock totaling some 13 billion tons[18] The potash problem, a serious one during the last World War, has been solved so effectively by our chemical engineers that we are now quite independent of the rest of the world for the salts of this element. Finally, there is no dearth of limestone, the use of which in adequate amounts to control the natural acidity of the soil solves the problem of any possible deficiency of calcium.

It may not be amiss in passing to direct attention to the fact that modern warfare would never have been possible on its present gigantic scale had it not been for the discovery and perfection of the means of taking nitrogen from the air by factory procedures. Yet when Sir William Crookes addressed the British Association for the Advancement of Science on this subject some forty years ago and pointed to the possibilities in the production of chemical nitrogen from the air, he was not thinking of war. In fact, his primary concern had to do with the wheat crop which, unless more nitrogen was forthcoming than was available

[16] The produce of some 80 million acres of land were exported from the United States to Europe annually for several years, beginning immediately after the armistice of the last war was signed.

[17] That portion of the rayon which is made entirely from wood now constitutes between 7 and 10 per cent. of our clothing materials.

[18] It is believed by some of our conservationists that, other than the soil itself, phosphate rock is by far the most important natural resource which this country possesses.

from the nitrate deposits of Chile, could not, in his opinion, be made to continue to yield enough grain to meet the needs of the wheat-eating peoples of the earth. It was Crooke's opinion that there was an important connection between the eating of wheat and the degree of civilization of a nation, the peoples who were fed on rye or rice never attaining to the highest culture.

But notwithstanding the contributions of the nitrogen of war to the arts of peace, the cost of replacing the elements of fertility which crops remove from the soil does become disturbingly large. Our yearly consumption of lime and fertilizers in the United States now amounts to some 25 million tons annually, costing farmers around 250 million dollars. And these tonnages, of necessity, must be enormously increased when the virgin fertility of the Corn Belt soils has been exhausted and the need for restoring their productivity becomes increasingly imperative For example, the annual fertilizer consumption on the relatively new soils of Iowa, with 34 million acres of land in farms, is now only about 17,000 tons, whereas New Jersey, with a farm area one-eighteenth that of Iowa, consumes 184,000 tons of fertilizer per year In other words, the rate of consumption of fertilizers per acre of farm land in New Jersey is over 200 times that in Iowa When the time comes that the virgin fertility of the Iowa soil has been exhausted, and the farmers of that State have to apply the millions of tons of fertilizer its soil will require, a serious economic problem will have arrived "out where the tall corn grows "[19]

Yet fertilizer and liming costs, though high, are insignificant in comparison with those involved in bringing water- and wind-eroded soil back into production In fact, about the only economic thing that can be done with badly gullied land is to let Nature, aided by the forester and the ecologist, take over the job of reclaiming it. This is a time-consuming process. Such enterprises are of the long-time, low-income type which normally are of interest only to governmental agencies.

It is conceivable, of course, that present agricultural procedures may, in due time, become as obsolete as has the forked-stick method of our far-distant forefathers for plowing the soil. There is no longer any question about our ability to grow plants without the use of the soil—and on a large scale[20] But scientists are not content with that accomplishment. Careful search is now being made for the secret of the chlorophyll of green plants through which the sun's energy is translated into carbon compounds. There is reason to believe that, by microbiological and chemical procedures, we shall ultimately be able to synthesize every one of the organic compounds contained in plants and required by animals Only the essential mineral elements would then have to be added to these synthetic products to yield complete foods Such foods could be artificially flavored and colored, and they could even be molded into appropriate shapes to satisfy our aesthetic senses.

But with a world war waging it seems safer to depend upon the soil, and the crops that grow on it. And if we are to place our primary dependence there for many centuries to come, as we very probably shall have to do, it would be well to recognize that the "Good Earth" must be kept good both during and long after the war, and that the well-being of those who cultivate the land as well as of the land itself is a matter of concern to all of us. For the farmer is the modern Atlas on the strength of whose shoulders the security of the world, in surprisingly large part, depends.

[19] It would appear that the relative economic position of the farmers of the eastern states would be much improved when the virgin fertility of the Corn Belt soils has been exhausted and the farmers of that area are compelled to increase greatly their expenditures for soil-improving agents.

[20] It is possible that the solution-culture method of growing plants, using sand or gravel for standing room, may undergo considerable expansion after the war is over.

MAN'S LONG STORY

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We live in a time in which human values, built up slowly through centuries with untold sacrifice, are threatened with destruction; when nations at either end of the old world have set out on a career of world conquest with the intention of exploiting and enslaving the conquered peoples, and are pushing that aim with sub-human brutality; when our own country is fighting for its life It is a time of fear and uncertainty. It is a time of human tragedy, when for millions the future is black indeed Can science help us to an understanding of what has taken place, or give us a perspective with which to judge the present, or point to any hope for the future?

I

We need perspective, the perspective of a long past. Swept along in the rapids of present-day happenings, we are in no position to judge them We need to stand on the bank, watch the river's rush, get some notion of its whence and whither. It were well to turn to the history, American history, European history of the last six millenniums We have gone far since neolithic man started civilization on the flood plains of the Nile and in Mesopotamia Other times have been worse than this, bad as it is. On the whole there has been advance

We need a longer perspective even than that of the last six thousand years, a perspective that science alone can give. The master historian is the geologist; he deals with time on a scale which dwarfs ordinary history. To him, as to the Creator, a thousand years are but as yesterday when it is past and as a watch in the night. He speaks of a hundred million years with the same nonchalance that the ordinary historian displays in handling centuries; and if he misses by a million or even ten millions when he is talking big, he sees no need of apologizing

That the earth is old, very old, has been known for the last two centuries, ever since the birth of geology as a science But how old in years? Recently the discovery of radioactivity has led to a new and apparently reasonably accurate method of estimating geological time Uranium by the loss of helium passes into lead The rate of such loss has been determined in the laboratory. By comparing the amounts of uranium and uranium-derived lead in certain granites we can find the age of the granites, and a minimum age for the sedimentary rocks in which they have been intruded. Thus are obtained the data for the following table, which shows the periods into which the geologist divides the past history of the earth, with their respective lengths:

Period	Length	Length of time to beginning of (in millions of years)
Cenozoic (time of recent animal life)	60	60
Mesozoic (time of medieval animal life)	130	190
Paleozoic (time of ancient animal life)	300	490
Pre-paleozoic	1300	1790

These figures are approximations at best; still, we shall probably not go far wrong in fitting our thinking to this

schedule. It gives us some two billion years for the age of the earth as recorded in the rocks. Back of that is an indefinitely long, early planetary period of which the geologist has no record.

II

Time as mere duration is uninteresting. It is what happens in time that matters. The length of geological time has been emphasized not on its own account, but because probably during the whole of that time there has been life on the earth, slowly, very slowly developing into the variety which we see about us to-day. Time is the background for the story of life.

The ancestry of man is a long one It goes back beyond Neanderthal man; belond the ape, the early mammal, the fish; beyond whatever invertebrate ancestor the fish had; back to some single-celled form in pre-Paleozoic seas nearly two billion years ago A long time for man to be at school. Progress has been slow, for Nature is a severe school mistress. Failure in her school means more than just waiting over a grade; the organism is thrown on the discard. She insists that her lessons be so learned that they become part and parcel of the organism, and she takes all the time necessary to secure that end.

Somewhere in the pre-Paleozoic sea existed single-celled ancestors of man, possibly like the ameoba. It could eat, assimilate, breathe, move, reproduce, all in very simple ways; but these were the essential functions of life. It was perfectly adapted to its environment; so perfectly that some of its descendants, still amoebae, are with us to-day. It was no newcomer into that early ocean; it had been at school for tens, perhaps hundreds of millions of years, and the lessons of that infantile grade had become a part of its very structure and function. We come along perhaps a thousand million years to the mid-Paleozoic, the Devonian, the age of fishes. Our ancestor is now a fish, admirably adapted to its medium, doing the same things the amoeba had been doing, but in a more elaborate way And there were those millions of years of schooling between Some of the Devonian fish, certain ganoids, were ready for a higher grade. In these the swim-bladder opened into the throat, and *in extremis* could be used for gulping air, that is, breathing. The fins were stout, and again, *in extremis* could be used for crude walking. Imagine these ganoids, caught season after season in time of drought in muddy pools on the Devonian flats, gulping air and floundering about, half in and half out of water. It was hard schooling, but some graduated; the air bladder developed into a lung, the fins into legs; and these ganoids were the ancestors of all the higher vertebrates In the monotonous uniformity of the sea, evolution of the higher types of life would have been impossible; that required the variety of the land surface. The coming to land of these Devonian fish has been said to be "the most momentous step in the whole advance from amoeba to man."

Two hundred million years further down the line we are in the mid-Mesozoic. Great reptiles rule the air, the sea and the land. It looks as if their future were secure, that their reign would last forever. It did last for more than a hundred million years. But the future lay not with the reptilian giants, but with certain small primitive mammals, an offshoot of the line of reptiles. They had been waiting their chance for some tens of million years At the beginning of the Cenozoic, Nature took them in hand for training for the higher grades; sixty million years of schooling it was to be. One group, the primates, came in for a special education of body and brain that had a more direct human trend. The early anthropoids, man's line, were tree-dwellers. Toward the middle of the

Cenozoic our direct progenitors came down out of the trees, adapted themselves to the ground, spread beyond the forests, and assumed an increasingly erect posture.

The Cenozoic was sixty million years long. Its last division, the Pleistocene or Glacial, was one million Through this last period, which includes four glacial stages with long intervening interglacial epochs, man was slowly straightening up, increasing in brain capacity and intelligence, developing speech, inventing tools His prolongation of infancy, far beyond that of other mammals, carried with it increasing teachableness, and the lengthening of the period in which offspring were dependent on their parents led to the beginning of the family with its accompanying intensification of the altruistic sentiments, to the growth of the qualities which we consider most distinctively human

Early in the Pleistocene, forms recognized as man and not ape are found (Java, Peking and Piltdown man) Neanderthal man (*Homo neanderthalensis*) made his appearance in the last interglacial epoch; but it was not until the last glacial epoch, perhaps 50,000 years ago, that Cro-Magnon man appeared in western Europe, the first that is admitted to the present species (*Homo sapiens*), and whose descendants are doubtless with us to-day. Erect, with prominent chin, high forehead and brain as large as that of modern man, he was skilled in the use of simple tools, and his carvings and drawings and polychrome paintings are the admiration of anthropologists. Cro-Magnon man stands at a pivotal point in the world's history. He is the climax of two billion years of animal evolution Man's long preliminary education is now completed. The stage is set for a new act in the drama of life; whether comedy or tragedy we do not yet know.

The purpose of this emphasis on the length of life on the earth is to show that the race enters manhood with an immense animal momentum The Roman Catholic Church is said to hold that if it can have the teaching of its youth for the first seven years, it will guarantee them to the Church for life Nature is man's teacher, and she has had his early education for a vastly longer time proportionally than the Catholic Church asks for its youth Man has been in the distinctively human school less than a million years He was in the primate (not primary) division throughout the Cenozoic, sixty times as long He began his primary education as some single-celled form in the early pre-Cambrian ocean, possibly two thousand times as far back as the day when he was promoted to the human grade Nature has insured that he learn his lesson well; that the animal is so inwrought in him that he can never get away from it His human nature is a recently acquired and uncomfortably worn garment.

III

The first inference to be drawn from man's long animal inheritance is that he is primarily a creature of instinct His driving forces are hunger, sex, fear, crowd, combativeness. No one who has honestly looked into himself or around at his neighbors can fail to see this He is not a fallen angel, god-descended, mixed with animal clay. On the contrary he has risen from the animal level. Let us hope he is still rising, and has his eyes at times fixed on the stars. Unless we keep his animal origin and bias in mind, we can neither judge him fairly nor plan wisely for his future.

A second inference, indeed the obverse of the first, is that man is not a creature of reason. The zoologists when they named the human species called it *Homo sapiens;* man the wise! Whether they did this from egotism or wishful thinking or just for a joke, they were in error;

wisdom is not his outstanding characteristic. Reflective thought is a late acquisition and few have it in any large measure. The eighteenth and nineteenth century confidence in reason is now seen not to be justified by the reality For most people, even for the best of us most of the time, reason is the servant of instinct, finding excuses for what one wants or has already decided to do. It is rationalization, first cousin of wishful thinking, which is not thinking; it is merely wishing Here again honest introspection will give us the evidence; also observation of neighbors. If one wants proof in public life, he can follow the doings of the United States Senate, the resolutions of Chambers of Commerce, or the propaganda of nations at war. If he looks for it in the rarefied air of abstract thought, he can dip into any book on astrology or even theology.

However, man's being primarily a creature of instinct furnishes a needed conservative and conserving factor. His animal inheritance keeps him on the track, keeps him from going off into all kinds of wild disintegrating experiment. But had this been the only force at work, man would still be on the animal level; progress would be impossible. Sane human history is a balance between the conservative instinct we inherit from our animal ancestors, and the use of reason to guide that instinct

Again, a clear appreciation of the strength of man's animal inheritance shows us that it serves to qualify both our hopes and our fears. It works against optimist and pessimist alike. The optimist expects that evil can be overcome, and that, speedily; that some sort of golden age or millennium is coming in the not distant future. The pessimist is sure that evil is with us to stay, and that to fight against it is a hopeless adventure. Both to the extreme hopes of the optimist and to the extreme fears of the pessimist the long biological-historical view is a corrective. The momentum of an age-long inheritance is not easily changed. The animal in us, often at odds with our idealism, will carry on indefinitely. But other forces are at work. We are told that we can not change human nature. But human nature can change. It has changed. We are what we are because it has. There is no good reason to suppose that it has ceased changing But the process is extremely slow Further, whatever may be said of human nature, human behavior can be changed, both in the individual and in the mass, and it is behavior that counts Recent events in Germany may not be proof of any change in the human nature of the Germans; but they certainly bear witness to a change in German behavior; and it is German behavior that the rest of the world has to deal with. It is equally possible to shape human behavior to good ends.

IV

Organisms must adapt themselves to their environment as the very condition of survival. If a satisfactory adjustment has been achieved and then the environment changes, a new adjustment must be effected; and that is always difficult. The course of geological history is strewn with the relics of species that, failing in adjustment, perished. The application of this principle to man is this: man's body and mind reached its distinctly human stage in one type of environment, and he has lived on into a radically different type, which he has himself created, and he is having tremendous difficulty in making the necessary adjustment.

The environment of early man was that of forest, or forest and plains, suited to hunting; or, if he was near the sea, to hunting and fishing. It was an active life in the open. He needed neither golf course nor gymnasium. He got his food from plants that grew wild, or from ani-

mals of the chase; at any odd time, not thrice daily o' the clock. It was one continuous struggle against cold and hunger. Eternal watchfulness was necessary that he get the animal before the animal got him, for both were out for a meal. Strength of limb, keenness of eye and ear, accurate knowledge in a narrow field counted for more than familiarity with Plato or the calculus would have done. On them hung the issues of life and death. Dense population was impossible; there was not food enough If population crowded on food supply, then war, starvation or infanticide kept it down. It was a life close to elemental nature, a life in which every normal adult could and did share somewhat equally, had his chance, and was on the whole equal to the situation.

All that is a matter of far away and long ago. Some thirty thousand years separate us from Cro-Magnon man Two great environmental changes have taken place. The first, to a settled agriculture, we see already accomplished at the beginning of recorded history, some six or seven thousand years ago Man at that time possessed domestic animals and cultivated grains; and on this basis he had established permanent agriculture on the rich, level, well-watered flood-plains of the old world. This permitted the accumulation of wealth, the growth of dense populations, commerce by land and sea, together with arts and industry, and the development of social classes. It permitted war, conquest and slavery. Still, the great mass of the people, the farmers or peasants, lived an out-door life not greatly different from that of the earliest hunters.

The second change, a revolutionary one, the greatest of all in man's environment, began some five hundred years ago. We find ourselves today in the very rush of it. Our age has been called, not wholly accurately, the age of science; the age of technology would be the better term. Technology has been slowly growing, as a process of trial and error, from the very earliest times. The pyramid builders in 3000 B.C. had a high degree of technical skill Man has not been so stupid that he has not been able through the centuries to improve the old ways, to find both new things to do and new ways of doing them Invention, quite apart from scientific research, has made great advances in the last two centuries. Mere enumeration is all that is necessary: iron and steel, fuels (coal and oil) for power, transportation, the factory, mass production; all this culminating in crowded peoples and overgrown cities For a while industry and new-born theoretical science followed separate paths. There was nothing in the early experiments in electricity to suggest the gigantic electrical developments of today. Science was largely the experimenting of individuals working alone. Slowly it became clear that science could be of use in human affairs It was first pity, then endure, then embrace Governments began to see the advantages of subsidizing geological, agricultural and medical research. Today most large industrial corporations support their own research staffs Science and big business have entered into partnership, and technology advances by leaps and bounds. It is reported that $235,000,000 were set aside by industry for scientific research in the United States in one depression year. Whether in the end this union of business and science will be for the world's good, it is too early to say. It has made possible mass production and the modern city. Following, as it has, the discovery of new continents, it has led to commercial rivalry, the exploitation of weaker peoples, the demand for new markets and new sources of raw materials, race antagonisms and world wars.

It goes without saying that man himself has produced this new environment.

Nature with no help from man shaped the environment in which he acquired his mind and body. But to a large degree he has taken over from Nature the building of his environment, has already tremendously changed it, with what results we are beginning to see He must now work out his destiny in a world amazingly different from that of any epoch of the past.

This change to a technological environment is inevitably accompanied by maladjustments which reach into every aspect of life The dwellings in which we live, whether the tenements and shacks of the poor or the air-conditioned apartments of the well-to-do, are a sharp contrast to the open-air life of man's formative period. The specialized and monotonous work of the miner or factory hand is slavery compared with that of the early hunter, which, if strenuous at times, lacked neither variety nor interest, and was a real education The deep canyon-streets of the city, filled with noise, gas, dirt and rush, or the drab surroundings of the factory town, are a sorry alternative to the open country. Two views of lower Manhattan, taken more than three centuries apart, would symbolize the change. One, today, would show the wonderful sky-line of high buildings, the other the wooded island Hudson saw when he entered the upper bay in 1609

The human element in the environment has changed no less than the material. The pace of modern life and the intellectual level on which it is carried on, make demands beyond any that were made on early men, demands which many can not meet. Modern industry finds many unemployable persons. It requires more from those it takes on, and scraps those it can not use with the same lack of consideration with which it scraps outworn machinery. It imitates Nature in her harsher moods.

The results? Before the war, between five and ten million unemployed in the United States, facing the choice between public support, starvation or crime; worse, unemployables; poverty, economic insecurity and recurrent depressions. Clearly the economic system is not working satisfactorily. Sickness: the medical bill of the United States is some three billions a year, and large numbers get no medical care Defectives and insane: mental cases in hospitals rose from 63 7 per 100,000 in 1880 to 263 6 in 1934 The total annual cost of crime, direct and indirect, in our country runs into the billions This tremendous load; unemployment, including the idle rich, crime, sickness, waste, class struggle, and worst insanity of all, war; all this is loaded on the backs of the actual workers on farm, in factory and office. This is the "white man's burden," not his egotistically assumed overlordship of races of another color.

V

What of the future? Physical conditions alone considered, there is every reason to believe that the earth will be a suitable home for men for a long time to come. And long here means long; tens of millions of years, perhaps hundreds of millions. There is nothing in the geological past to suggest any speedy windup of mundane affairs. If some wandering star approaches our sun and upsets things, or if the sun blows up, as suns (novae) have been known to do, or if in the far distant future our central sun becomes cold, that will end us But such contingencies are almost infinitely remote, and the scientist, as a student of earth's history, is justified in ignoring them.

Climatic conditions will continue to be favorable. When the extent of the continental glaciers of the northern hemisphere was first appreciated, it seemed as if the earth might be cooling down; that

we were about to enter upon a long period of refrigeration, in which human life would become increasingly difficult, and finally end. We have since learned that glaciers are no new thing in the earth's history. There was extensive glaciation at sea-level in India, South Africa and South America at the end of the Paleozoic, perhaps two hundred million years ago. Another extensive glaciation occurred twice as far back, before the beginning of the Paleozoic Climatic changes seem to have been rhythmic instead of progressive; swings from warm to cold, and back again; from wet to dry and dry to wet; but at all times of a character to permit human life, had it been in existence There is no reason to suppose that conditions will not continue much the same in time to come. The weather prediction for the future is "favorable" Today's climate, like all weather everywhere, is "exceptional" We are still in the fag end of a glacial period, with immense ice-sheets in Greenland and Antarctica, and abundant mountain glaciation There have been four glaciations in the Pleistocene It is quite within the realm of the possible that another ice sheet may develop in Canada, push south into the United States, and overwhelm New York, Cleveland and Chicago; the last ice sheet reached that far The next, if there is a next, may do the same It will not be a glacial blitzkrieg, however There will be plenty of notice in advance And it will be exceptional Through most of the past the climate has been mild and uniform, and it will probably be so through most of the future

The surface of the earth has been the scene of an age-long battle between elemental forces Century by century the rivers have been sweeping the debris of the land to the sea, and the rising sea has been creeping up over the borders of the continents If these were the only agencies at work, the continents would be reduced to submarine platforms in the course of a few million years But always, in the past, before that has happened, internal forces have raised the surface of the continents, and the rivers and the sea have had to start all over again. This rhythm of erosion and renewal by uplift has been going on since the beginning of geological time There is no reason to suppose that it will not continue through an indefinite future. Man can not stop it, but he can adapt himself to it In the distant future ocean waves may again wash the sites of New York and Chicago, Cleveland and St Louis, as they have in the remote past, but there will be land somewhere, and the changes will come about so gradually that there will be abundant warning that moving day approaches

The environmental aspects just mentioned are exempt from interference on the part of man Others are not Man cuts the forest, plows the grasslands, and plants his corn and wheat He digs or drills the ground for his fuels and his metals These are his resources for food, for industry. How is it faring with these natural resources?

First, as to the food supply. There will be enough to eat, if . There have been times in the past when a land animal like man would not have found enough to eat, enough of the right kinds of food When the lung fish of Devonian times came ashore to become the ancestor of vertebrate land life, he found an abundant vegetation. But it did not contain our present foods None of the plants which fill the spring seed catalogues were ther in existence Flowering plants did not come until late in the Mesozoic, nor were grasses and grains, man's basic foods, abundant until the Cenozoic But now they are with us. Nature has done her part "Behold I have given you every herb yielding seed, which is upon the face of the earth, and every tree, in which is the fruit of a tree,

yielding seed; to you it shall be for food." What man is doing at improving this endowment is told in the splendid story of modern scientific agriculture.

But plants require soils; aye, there's the rub! We are waking to the fact that soils are being destroyed in this country at an alarming rate. They are being washed to sea by the rivers and blown away by the winds. Already from one quarter to all of the top soil has been eroded from 59 per cent of the United States. They are being impoverished by cropping without any return of the essential elements taken. Soil loss is a serious national threat; soil conservation a great national problem and need. The soil is a resource which can be used and kept. Soil exhaustion is not necessary. Some soils have retained their fertility after thousands of years of use, but it has been intelligent use.

Resources such as soil and water, if properly handled, can be used and kept. With them you can eat your cake and have it too. It is different with most mineral resources. The fuels—coal, oil and gas—are stored supplies of organic origin which have come down from the geologic past. If they are forming anywhere today, it is at a rate which is infinitesimal in comparison with that with which they are being used up. The supplies of coal and oil are limited in amount, and when they are used up they are gone. There is a certain coal tonnage still in the earth. Its amount is fairly well known. How many years it will last depends on so many factors that no accurate forecast can be made. Those already made speak not of decades, nor millenniums, but of centuries. The story of every oil field is one of discovery and exploitation, followed by slow decline to exhaustion. There are a definite number of oil fields in existence. Some are known, others are yet to be discovered. When the last field has been discovered and exhausted the supply of petroleum will be gone forever. Then, unless something is invented to take its place, we shall be driven to the distillation of oil from oil shale.

Coal and oil are fossil sunlight, the sun's energy stored up by plants of the geological past. Plant life today is temporary storage of the sun's energy. It may be that before these supplies are exhausted our physicists and chemists may hit on some way of directly catching the sun's energy, that future housewives may can sunlight along with peaches and tomatoes for winter supply. Or will the Sunlight Company of America establish a monopoly?

Metals, too, occur in limited amounts. They are concentrations, mainly by underground waters, of elements that in their original condition were so scattered through the rocks of the earth's crust as to be valueless. This is an age of steel; but in order to make steel there are required, besides iron ore, nickel, manganese, chromium, vanadium and other alloy metals. These occur in small amounts and are widely distributed over the globe. In all, the supply, whether large or small, is definitely fixed in amount. Metals are a limited and exhaustible resource, and they demand the most careful conservation.

If we take the long view, there would seem to be but one conclusion that we can draw from the limited supply of mineral fuels and metals, and that is that there is a fixed period set to the age of iron and steel, as we now know it. A careful use of our mineral resources may prolong its life, perhaps for a few thousand years, and substitutes for the metals will help. But it looks as though in the end it may be necessary to return to conditions like those which preceded the nineteenth century. Doubtless some would look on such a change with resignation. They are asking whether the Sunday paper, movies and radio, battleships, tanks and planes, and much of the

rest of modern production, have really raised our cultural level. Were not many men in Shakespeare's day living as full lives as any of us now?

To sum up: Nature has done her share to insure a favoring home for man for an indefinitely long future. If things do not go well, he has but himself to blame

VI

Will man himself change, in body or mind? And if so, in what direction? These are questions impossible to answer. There seems to have been no significant change in his body since the beginning of the historical period. But in considering his future we have to do with not thousands but millions of years; tens, possibly hundreds of millions There was immense evolution along many mammalian lines during the sixty million years of the Cenozoic; great changes took place in the human stock during the last million, since the first glacial period.

In the past, forms often became narrowly specialized, well fitted to a particular environment; and when that environment changed they were unable to adapt themselves to the new conditions, and perished Man is a generalized form, a sort of jack-of-all-trades He can run, but not like the deer; climb, but not like the monkey; swim, but not like the fish, and he can fly. But he has what birds, beasts and fishes have not, fingers and a superior brain. He can think; and by thinking he has, with his unspecialized body and hands and with the tools his hands have made, devised means for beating each of the others at their own specialty It is probable that man will continue much as he is now, using his intelligence to secure his adjustment and his continued life.

That man has advanced mentally during historic times might seem to be a good bet; but it is one that can not be collected on, since there is no way of establishing the facts. Certainly the eminence of the Greek intellectuals proves nothing. With all their ability the Greeks were unable to weld together the small Greek states and prevent their overthrow by Macedonia and Rome And it is a fair inference that Newton, Darwin and Einstein, Shakespeare and Goethe, and those who are organizing the complex industrial life of to-day, are at least the equals of the glory that was, for a short time, Greece

With man a great change has come in the evolutionary process In the past, evolving forms have been quite unconscious of their own development. For man this is no longer true He knows the long course he has come, he discovers the factors at work in his own heredity and environment, he can look into the future, and he is able in a degree to take control of and direct his own evolution He is already directing the evolution of the animals that are useful to him; the rest he exterminates. What he has done in producing different breeds of cattle, swine, sheep and poultry, a visit to any state fair will show. After such a visit one may conclude that it is just as well, in view of his present ignorance, that man has not yet begun to experiment in this way on himself. But the possibility is there.

VII

Man's evolution now is primarily social and cultural It has been going on since earliest man; its description is the burden of history. And in spite of the wails of the pessimists its progress has not been slight. So it will continue to be throughout the immediate future, say for the next ten or hundred millenniums. As in biological evolution, there is variation (by the introduction of new ideas), heredity (in the sense of transmission by tradition), and struggle for survival, both within and between groups. That struggle is everywhere present in current American life, and is now going on

on a world scale with furious intensity in the present war. As with biological evolution, cultural evolution has been mainly unconscious and altogether unplanned; but here, too, man has reached a stage when he could in a measure take it in charge.

One important aspect of social evolution is the development of consideration for others, of the idea of right and wrong, of morality. Animal nature is non-moral The question of right and wrong does not exist when the wolf drags down the deer Consideration for others began with the early family. The long period of human infancy, close-spaced births over the woman's bearing period of thirty years or so, held the family together In such soil thought for others had a chance to grow Man's susceptibility to the favorable or unfavorable opinion of others helped. As a result there has come that slow growth of sympathy for others which has raised the struggle for existence above the animal level. It is these and other distinctly human traits which make life worth while

To the development of altruism there is one chief enemy, our increase in numbers Man, like all other animals, tends to multiply beyond the means of subsistence When there are more mouths to be filled than food to fill them, when there are more men than jobs, the fight for food and jobs begins. Self comes first "Skin for skin, yea, all that a man hath will he give for his life" We are each of us conscious that there is a limit beyond which our sharing ceases Bare necessity pushes aside sharing and brings back the struggle for existence to the jungle level.

Huxley in "Evolution and Ethics" has drawn a picture of a garden cut from a wilderness The gardener clears out all except the chosen varieties, nor are these allowed to crowd Plan, the gardener's will, replaces struggle. But to maintain this the gardener must remain on the job; if not, the wilderness creeps in and in a short time no trace of the garden is found So with the higher values which man has evolved up through history. They have been built up with infinite care, and continued care is the price of their preservation.

VIII

What are some of the first steps that should be taken in planning for the future? The foremost need is a clear-cut human ideal, the envisaging of "the highest human values realizable on earth through human effort" (Max Otto) This comes close to the democratic ideal, namely the fullest development of the possibilities of every individual, both on his own account and for the service he can render the world, the state being guardian, not master or slave driver. Each man to have his chance It means the end of race discrimination The claim of superiority by Europeans over non-Europeans has done immense harm to both.

In giving content to this aim, science, that is, knowledge, must help. Science, some say, has brought us to the mess we are in True, technology rests back on science, but science is not responsible for technology, nor is technology responsible for the uses made of it. For that we are all responsible, through our stupidity and selfishness We need to know vastly more about man, his heredity, the effects of his environment, the way his mind works Millions are spent for research in technology, for improving glass, rubber, corn and hogs; very little for the study of man himself! One sickens at the billions now necessarily given for war, all of which would be unneeded in a decently ordered society; and thinks what tremendous advances the wide use of a fraction of that wealth would bring about if devoted to the problem of man Just one hundred years ago Longfellow wrote:

> Were half the power that fills the world with
> terror,
> Were half the wealth bestowed on camps and
> courts,
> Given to redeem the human mind from error,
> There were no need of arsenals or forts

We must revamp our economic system We have the resources for a decent life for all. Poverty is no longer a necessity, it is a curable disease, and it is our shame that it is still with us. Our resources must be used for the good of all and not for the profit of the few We need a new commandment, "Thou shalt not waste!" And we need to put new content into that old one, "Thou shalt not steal" This reconstruction will have to be done on a world basis, for science and technology have so drawn the world together that what is harm to one is now hurt to all.

Education must help, but it must be an education fitted to our present needs, not one that is an inheritance from an alien and aristocratic past It must be an education that fits for jobs, trains leaders and gives a satisfying philosophy of life An education that makes it forever impossible for one to forget that all that he has comes to him not through his own efforts, but because of the sacrifices of those who have gone before; and that he is not only a citizen of a national state, but a member of a world society Above all separate groups is mankind.

IX

Let us gather up the threads of the argument. Nature has provided bountifully for man for an indefinitely long future, has given him ground to stand on, food, shelter, resources of all kinds for an abundant life She has given him a brain far and away ahead of any other of her creatures, which makes it possible for him to take charge of his own affairs But man is stumbling He has radically changed his environment, and is finding it passing hard to adjust himself to it He has called spirits from the vast deep and they have come, but he has not learned how to control them

He finds himself at the forks of the road Shall he drift and drift to destruction, or shall he take the problem of his future in hand and solve it? There is no question but that he has the necessary intelligence The mind that can weigh the infinitely distant stars and tell their make-up, that can track down the minute carriers of disease, read its own history in the rocks, that can dig the Panama Canal and dam the Columbia River at Grand Coulée, that can run great railway systems with the accuracy of a watch, and build and keep functioning cities like Chicago and New York, can solve its social problems when and if it decides to do so It is ourselves and not our stars that are at fault if we do not.

PHYSICAL SCIENCE AND PHILOSOPHY[1]

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THE relations of science and philosophy are matters of lasting interest and concern to man. In times of peace, it is a noble expression of creative activity that leads us to turn our excess energies —away from the pursuit of easy pleasures—to the disinterested study of relations which underlie our understanding of reality. In times of war, when excess energies for serious study are no longer available, we can still refresh ourselves by turning aside to a brief contemplation of matters that once concerned us deeply, and—God willing—will concern us deeply once again Renewed by this refreshment, we can then return in good heart to our immediate tasks in the struggle for that kind of a world where man will again have the energy, the freedom and the disposition for disinterested creative thought.

The title "Physical Science and Philosophy" is a very broad one which was assigned to this paper in order to fill a place in the symposium planned in the honor of Newton. Under that title, I should like to present certain modest philosophical reflections as to the nature of science, with illustrations drawn particularly from physics In formulating these reflections, it will be taken as agreed that it is the business of the sciences—physics, chemistry, physiology, biology, and so on, each in its own field of concern—to undertake a systematic and intensive program for the discovery, correlation, control and prediction of the phenomena of nature It will also be taken as agreed that it lies within the wider business of philosophy to examine the assumptions underlying the methods of the sciences, to present a coherent synthesis of the results of the separate sciences, to evaluate the grounds of knowledge itself, to set forth the differences between the beautiful and the ugly, to expound the principles of right and wrong, and, based on such considerations, to attempt an integrated view of reality as a whole.

In accordance with the character of its own limited range of activity, the methods and results of science—unlike certain of those of interest to philosophy—may all be characterized as objective and abstract The methods and results of science are objective, since success in the discovery, correlation, control and prediction of the phenomena of nature is a matter upon which substantially common agreement can be obtained. The methods and results of science are abstract, in the first place, since science abstracts or selects out from the general considerations which men give to their experience only that kind of treatment which actually is objective; and in the second place, since each particular science abstracts out from the general field of science its own particular field for systematic and intensive study. I shall relate my proposed remarks on the nature of science to its objective and abstract character.

Let us first say something about the objectivity of science The test of objectivity is that of common agreement and acceptance, and new scientific discoveries and principles achieve objectivity and are incorporated into the body of

[1] From the symposium on "Natural Philosophy" commemorating the 300th anniversary of Newton's birth which was to have been presented at the New York meeting of the American Association for the Advancement of Science.

science as they meet this test. To satisfy this test it would not be proper to demand absolutely universal agreement and acceptance, but only that of diligent and competent men who have made an unbiased examination of the matter in question. As most scientists sadly know, there is a lunatic fringe of men who use scientific jargon to say things that are untrue or foolish Indeed, there is a tendency for members of this fringe to organize into definite cults, such as flourish in considerable number in the neighborhood of my home in Southern California. In addition, and much more serious, there can arise groups of mendacious men who purposely devise false sciences—for example, theories as to racial culture and superiority—with which to delude and control their fellow countrymen.

Under the circumstances there are, to be sure, some difficulties in applying the test of objectivity, and in deciding which are the diligent and competent men to be depended upon for the unbiased examination of matters in question. Nevertheless, these difficulties are held in check by two important factors. In the first place, most men are in fact sensible men, and when the diligent and competent scientist shows them a newly discovered phenomenon and teaches them how to control it, they can for themselves distinguish truth from falsehood In the second place, the results of science have a compelling pragmatic and survival value which makes it perilous to deny them. When the leader of a small mountain cult, denying the principles of physiology, subjects his child to the bite of the rattlesnake, the ensuing disaster results for all to see When a nation, denying what science can say about the culture of different peoples, believes in the divinity of its emperor and follows the lies of the manipulators that surround him, its folly will be demonstrated either by the swift processes of war or by the slow grinding of the mills of the gods.

As a consequence of these two factors, there are no permanent difficulties in obtaining substantially common agreement as to the facts and principles to be accepted by science, and the objectivity of science persists as its most highly valued attribute It is indeed no mean achievement to employ methods and obtain results that must be approved by all men at their peril

Before leaving this discussion of objectivity two remarks may be made with reference to the contrast between the complete objectivity of science and the incomplete objectivity of philosophy.

The first of these remarks has to do with a possible but fallacious criticism of philosophy by scientists. Impressed by the possibility and importance of obtaining results that must be agreed to by all, some scientists tend to regard it as a perverse frivolity that leads philosophers to include methods and results which are not objective. This, however, is an unfair reproach, since philosophy includes within its scope epistemological questions as to the grounds of knowledge, aesthetic questions as to what is beautiful, and ethical questions as to what is good, concerning which there is not, and to some extent there can not, be common agreement This becomes especially clear in the field of ethics, where it is evident, at least from a practical point of view, that different men have different ideas as to what is good and bad—for example, the Nazis and ourselves Discussion of the extent to which objectivity might also be achieved in such fields as aesthetics and ethics must be left for another time.

My second remark has to do with a possible but fallacious criticism of science by philosophers. The circumstance that men's philosophies may make use of methods and results which are subjective, while science can only include methods and results which are objective, might

lead some philosophers to the suspicion that there are certain whole fields of human experience which are barred from scientific investigation. This suspicion, however, is not correct The true state of affairs is merely that in investigating such fields science confines itself to objective studies Thus it is within the province of the scientist—for example the anthropologist—to investigate the systems of ethics actually held by different peoples, and indeed to study the consequences of holding different ethical views The anthropologist steps out of his role of scientist, however, when he advocates—as it well may be desirable to have him do—one system of ethics rather than another The fact that there are no fields of human experience which are barred from scientific investigation, is an important one, since there are many differences of opinion between men which are not due to actual differences in subjective point of view, but to incomplete understanding of the objective phenomena involved Thus when men, who advocate different ethical practices, come together for discussion, they often find that some of their differences can be reconciled by a scientific examination of the consequences of those practices Hence, even though science can not resolve fundamental subjective differences between men, it can make its own important objective contributions in any field of human interest

Let us now turn to a consideration of the abstract character of science It will of course be appreciated in this connection that all kinds of human thinking are in any case actually abstract, since it is beyond the power of the human mind to deal with all aspects of a situation at once, some parts have to be abstracted or selected out for immediate treatment, and other parts neglected or left for later consideration With regard to this inevitability of abstraction, however, philosophy and science adopt a somewhat different point of view Philosophy, on the one hand, tends to be depressed by the necessity for abstraction, is specially concerned with the distortion or error that may be introduced by the process of abstraction, is troubled by the partial view which results from abstract thought, and would like to present an integrated view of reality from which the harmful effects of abstraction have been eliminated. Science, on the other hand, tends to be exhilarated by the advantages which are gained by its own particular program of abstraction—these advantages being, of course, the general objectivity which is obtained by the focusing of science only on those aspects of any situation upon which common agreement can be reached, and the specificity and energy of attack which is obtained by the focusing of each particular science on its own special field of interest.

There are many interesting questions that could be discussed in connection with the methods by which science in general abstracts out from the situations which it considers, that which is objective These might include rather immediate questions as to the reproducibility of experimental measurements, the effect of environment on experimental results, and the use of statistics in analyzing experimental data and more psychological questions as to the criteria for selecting diligent and competent scientists, the effect of personal bias on results, and the relation between the subjective origins and objective outcome of scientific experiments. I shall make some remarks only on the last of these questions as to origins and outcome As a heading for these remarks, I shall take the title "The Scientist's Day—Subjective in the Morning, Objective at Night."

In the morning, the scientist leaves his home, goes to his laboratory, and shuts himself in—kissing his wife as he leaves, greeting his colleagues pleasantly as he arrives, and taking off his coat and buckling down to work as he closes the

door. In passing, we may note the subjective determinants of this early morning behavior: he kisses his wife to express regret for the coming day of separation, he pleasantly greets his colleagues to placate them for the apparatus he will swipe before night, and he buckles down to work to satisfy his intellectual curiosity, economic needs, ambition or some general urge to achieve. But our present concern lies in what determines the program of work that he undertakes. At least on the days of great discovery, he selects this program, —mind you—not to obtain objective results as rapidly as possible, but to satisfy his own subjective needs to test some hypothesis or to prove some theory.

The good physicist on entering his laboratory, and seeing his apparatus before him, does not say, "I shall diligently use this apparatus to make measurements of the kind for which it is fitted and obtain with dispatch objective values which can be commonly accepted." Rather, he says things such as the following. "I shall find out whether an electrostatic charge set into motion does have the properties of an electric current. I shall look for the effects which should result from the earth's motion through a stationary ether. I shall see if the electrons in a conducting metal do exhibit mechanical inertia. I shall look for the spatial orientation of atoms in an external field so astoundingly predicted by the quantum theory. I shall find out whether the neutrinos which have been postulated to conserve energy in radioactive transformations would also act so as to conserve momentum." The origin of such problems is a subjective one, and the great physicist is the man who has a feel for problems which are both significant and soluble.

At night, as the physicist walks home from his laboratory, he thinks over the doings of the day and questions the objective validity of his results. "Were those meter readings due to some leak in my circuits, or really caused by the motion of the charge on my rotating disk? Does that group of consistent interferometer readings actually mean a positive effect, or it is really properly explicable merely as a statistical fluctuation? Are those occasional wild galvanometer throws actually of significance, or really due to unimportant accidental causes? Were those lines on my plate merely an artifact, or really caused by silver atoms that have been deflected in the magnetic field and shown up by my process of development? Was that track in the cloud chamber a chance disturbance, or really an evidence of transfer of momentum?" On the basis of many such nightly reflections, that which has objective validity is finally abstracted out from the welter of subjective experience in which scientists as well as other human beings are immersed.

Let us now leave further discussion of the processes by which science in general selects or abstracts out that which is objective, and turn to a consideration of the circumstance that each particular science abstracts a particular kind of phenomena for its own field of special and intensive study. This is a matter of great interest, not only because the progress of science has been greatly affected by the resulting division of labor, but also because the structure of science and of the branches into which it is divided is dependent on the sets of abstractions that the different sciences do make.

At any given time, the actual structure of science is considerably affected by past historical accidents and is in a process of change as new phenomena are discovered, new concepts invented, or regrouping of existing concepts appears profitable. For example, at present it would seem to many that the old separation between physics and chemistry has now become an artificial one which is maintained as a result of unimportant historical accidents which have taught physicists to read meters and chemists to

look at test tubes, and that a consolidation of the two sciences should now be undertaken. Nevertheless, in spite of accident and change, there is a general principle, for organizing the sciences into a hierarchy in accordance with the levels of abstractions that they employ, which not only helps in understanding the structure of science at any given time, but also tends to give considerable stability and permanence to the structure itself

The possibility of making such a hierarchy of the sciences we associate with the name of Comte In setting it up we start with the sciences which abstract for their study the simplest and most general aspects of the world of phenomena and proceed to those which abstract more richly patterned and less general aspects Thus we pass from mathematics, which concerns itself with few and simple things such as number and order, to physics which adds motion, mass, electricity and the structural particles of matter, then to chemistry, which adds chemical substance and chemical reaction, then to the biological sciences, which add genes, cells, organs and organisms—and finally to such complicated sciences as psychology and sociology, in which the abstractions to be preferred are still a matter of considerable uncertainty We thus obtain a hierarchy of more and more complicated sciences Since the earlier sciences in the list provide concepts and methods which continue to be used by the more complicated ones, we often speak of the earlier sciences as more fundamental than the later ones We also often speak of the earlier sciences as being more abstract than the later ones, since the process of abstracting away from the total situation has been carried to a further extent.

In accordance with the character of such a hierarchy of the sciences, it is evident that the different sciences would abstract out for their particular study different aspects of one and the same external situation. To illustrate this, let us take the traditional guinea pig, or better yet, say a litter of four guinea pigs, three black and one white, and note the reactions of different scientists to this same external situation The mathematician will be interested in the circumstance that he has a collection of three plus one identifiable objects which can be arranged in various sub-groups and orders. The physicist will be interested in the weights of the different guinea pigs, their accelerations when acted on by forces, and the electromagnetic phenomena associated with their colors. The chemist will concern himself with the chemical constitution of the pigments in their hair and the chemical reactions going on in the bowels of the pigs The geneticist, as one kind of biologist, will be interested in the Mendelian distribution of the litter, with the genes for black pigmentation dominant over those for white. And finally, the animal psychologist will be interested in the overall behavior of the little beasties, for example their abilities to learn their way through mazes As a single illustration of the fact that a given science in the hierarchy may make use of more fundamental ones, we note the frequent use of mathematical notions by the psychologist, for example in plotting his learning curves, and in analyzing the statistical reliability of his results

Although the Comte principle for the organization of the sciences into a hierarchy is an important one and gives valid insight into the nature of science, we must not take it too solemnly. The principle has been logically useful in classifying the sciences rather than genetically important in determining the historical course of their development, which has not taken place in an orderly fashion from the simple to the complex by the inclusion of further aspects of reality. It is not the only principle needed in classifying the sciences, since at a given level of abstraction we may also wish to

introduce other distinctions—for example, between a basic science such as physics, which studies underlying principles, a descriptive science such as structural geology, which describes a class of concrete physical phenomena, an applied science, such as dynamic geology, which applies the principles of physics to the understanding of those phenomena, or an applied science, such as economic geology, which makes applications to industrial ends. Finally, it is evident that the Comte principle gives us no completely permanent classification of the sciences, but is a principle which is to be continuously reapplied to get new understanding as science develops.

The development of science results from two principle causes. the discovery of new phenomena, and the introduction of new explanations for known phenomena. I do not think that the Comte principle gives us any special insight into the sacred act of discovery, but it may be helpful in understanding the introduction of new explanations, which often consist in explaining, at least in part, the phenomena studied at one level of abstraction in terms of concepts introduced by a more fundamental science, at a lower level of abstraction

As an example of this, we may consider the explanation of chemistry in terms of physics At its own level of abstraction, chemistry investigated the phenomena of chemical substances, pure and mixed, elementary and compound, the phenomena such as solution, precipitation and fractionation by which substances could be mixed or separated, and the phenomena of the chemical reactions by which changes could be made from one set of substances to another And to explain the results of its findings, chemistry found it profitable to suggest the hypothesis of the atomic and molecular constitution of matter Following this —to give an oversimplified account—physics then came along and found it possible to subject the atoms and molecules suggested by the chemist to intensive study, and to show that these atoms and molecules were in turn composed of more fundamental particles which had attributes such as mass, linear and angular momentum, electric charge and magnetic moment—concepts with which the physicist was already familiar—and finally to show that all of these structures obeyed the laws of the new quantum mechanics With the help of these findings, it then became possible to undertake an explanation of chemistry in terms of the concepts of the more fundamental science of physics This explanation has turned out to be very satisfactory, quantitatively correct in simple cases that can be worked out in detail, and qualitatively illuminating in more complicated cases Indeed, the explanation has been so satisfactory that we now tend to regard chemistry as being—at least in theory—a part of the group of sciences that we call physics

In this connection, however, I should like to report remarks which have been made by two of my scientific colleagues My friend, Frau Ehrenfest, the mathematician and physicist, once remarked that chemists had always hoped for an explanation of their science in terms of physics, but were unpleasantly astounded when the actual explanation involved elaborate structures obeying the complicated new quantum mechanics, instead of simple rigid atoms obeying the well known principles of classical mechanics. In line with this remark, chemists may be expected for a long time to continue the use of older modes of chemical thought and expression, resorting to fundamental explanations in terms of ultimate particles and quantum mechanics only on occasions when this will be specially helpful. My friend, Otto Stern, who started as a physical chemist and became a great physicist, has remarked to me that perhaps a new principle might some day turn up to be necessary for explaining the behavior of great

numbers of atoms such as take part in ordinary chemical reactions, for example, some sort of a magnified Pauli exclusion principle. If such a principle should be found, it might then seem sufficiently different from the known principles of physics so that we should again wish to reinstate chemistry as a theoretically separate science

As another example of the explanation of one science in terms of a more fundamental one, I should like to take the case of thermodynamics and statistical mechanics Here following the methods of Gibbs, it has proved possible, also when quantum phenomena are involved, to correlate the concepts of the temperature and entropy of a system, which thermodynamics has specially introduced on its own level of abstraction, with mechanical quantities which describe the statistical distribution of ensembles of systems of similar molecular constitution This has led to a very satisfactory mechanical explanation of the phenomena of thermodynamics

I should like to mention three features of this explanation which illustrate kinds of features that turn up in other cases By making use of the hypothesis of molecular constitution, statistical mechanics finds it possible not only to explain the phenomena of thermodynamics, but also to explain other phenomena, having to do with the properties of matter and with the rates of physical chemical processes, which lie beyond the scope of thermodynamics. By not making use of the molecular hypothesis, thermodynamics places itself on a more immediate phenomenological basis than statistical mechanics, and for that reason still retains certain special merits as a theoretical method of treatment Finally, even though we accept the greater fundamentality and power of statistical mechanics, we shall often wish to continue the use of the language of thermodynamics, when possible, because of its greater simplicity and familiarity

There are, of course, other cases where at least a part of one science can be explained in terms of more fundamental ones Thus parts of sociology can certainly be explained in terms of psychology, parts of psychology in terms of physiology, parts of physiology in terms of physics and chemistry, and parts of all the sciences in terms of mathematical relations These possibilities are so frequent and important that we may well wonder where the process of explanation in terms of a more fundamental science will stop Perhaps everything could be explained in terms of mathematics. You will remember the belief of the ancient mathematician Pythagoras that "all things are numbers," and you may recall conversations of your own, with more modern mathematicians, who sometimes seem quite arrogant in their claims as to the scope of mathematics

In this connection, however, it appears to me that there really are natural limitations on the possibilities of explanation in terms of more fundamental sciences. Such a limitation arises whenever a truly new aspect of reality emerges for study as we pass through the Comte hierarchy from the more to the less abstract sciences I should like to illustrate this by considering the passage from kinematics, to dynamics, to electrodynamics In the science of kinematics, we consider the space-time behavior of massless bodies, on which we can impose such laws of motion as we desire On passing to dynamics we add the ideas of the masses of the bodies and of forces acting on them in accordance with Newton's laws of motion, and it will not be possible to explain away the essence of these new ideas by any appeal to ideas already present in the more fundamental sciences of kinematics and mathematics. Finally, on passing to electrodynamics, we add the new idea of electric charges that may be placed on the moving bodies and determine the particular character of the forces that act thereon; and this

again adds a new idea which can not be explained away in terms of previous ones

There are, I think, two reasons why we sometimes become confused as to the extent to which it might be possible to explain the less abstract sciences in terms of the more fundamental ones In the first place, since each science in the Comte hierarchy has the findings of more fundamental sciences available for its use, it is often the case that parts of its field of interest can be handled on a more fundamental level If we forget that there are other parts of the field which involve truly new aspects of reality which have not been present at the lower level, we may then come to the erroneous conclusion that everything could be handled by the methods of a more fundamental science In the second place, an occasion for confusion may arise from the circumstance that two different methods of approach may have been originally introduced for studying the same new aspect of reality When we later come to prefer one of these methods as more fundamental than the other, we may then be led to the erroneous conclusion that this is an example of a process of explaining sciences in terms of more fundamental ones to which there will be no limit Thus in the case of chemistry we have the phenomenological approach which makes use of the concepts of chemical substance and chemical reaction and the theoretical approach which makes use of the concepts of atomic physics And in the case of thermodynamic phenomena we have the phenomenological approach which is based on the second law of thermodynamics and the theoretical approach which is based on the statistical mechanical hypothesis of equal *a priori* probabilities for different molecular configurations When in these cases we come to regard the theoretical approach as giving a fundamental explanation of the phenomenological approach, we must not regard this as evidence that the really new aspects under study could themselves be explained away in terms of something more fundamental yet.

As an interesting example of the kind of problems that arise when we consider the possibility of explanation at a more fundamental level, I should like to make some remarks on the old controversy as to the possibility of explaining biology in terms of physics and chemistry This question often arouses a nearly vituperative interest On the one hand, the extreme vitalists claim that the behavior of living matter contradicts the laws of physics and chemistry, and on the other hand the extreme mechanists claim that the behavior of living matter can be completely explained by the laws of physics and chemistry I feel sure that the extreme vitalists are wrong, and think that the extreme mechanists very probably are In the first connection, it seems evident, merely as a matter of definition, that the behavior of living matter can not possibly contradict the laws of physics and chemistry, since the apparent occurrence of such a contradiction, in any situation where such laws were applicable, would merely be taken as a sign that the laws had not yet been properly formulated, and they would forthwith be amended In the second connection, it seems clear, even though the behavior of living matter can not contradict the laws of physics and chemistry, that this behavior might involve situations which were not completely explicable in terms of physics and chemistry, since laws of a kind that we would be willing to call physical-chemical could not be applied For example, as emphasized by Bohr, situations might arise in which a proposed physical-chemical study of the behavior of living matter might involve such drastic treatment as to kill the matter and thus defeat the desired study There is, of course, much in the behavior of living matter that can be explained in terms of physics and

chemistry, and it is my own feeling that for many decades longer the physical-chemical attack on biological phenomena will be highly profitable. It would seem to me presumptuous, however, to assert that this mode of attack would necessarily be all that will ever be needed for the scientific treatment of the behavior of living matter

As another illustration, which to my mind shows very clearly the inappropriateness of assuming that phenomena at one level of abstraction can necessarily be completely treated at a lower level of abstraction, I wish to turn to the ancient problem of free will versus determinism. The particular setting of this problem, that I have in mind, is the one in which it is asserted that a man's actions are determined by the processes which go on in his brain, and that these processes are themselves determined by the behavior of the atoms and molecules in his brain, and that this behavior in turn is itself subject to the laws of physical science. On the one hand, in the older days of the classical mechanics, this picture was then taken as making it certain that a man can not have free will, since his acts could be predicted by applying the laws of physics to the configuration of atoms in his brains On the other hand, in the newer days of quantum mechanics, this same picture has been taken as allowing a gratifying loophole for free will, since the Heisenberg uncertainty principle makes it impossible to predict the precise behavior of a system of atoms from a knowledge of its configuration Indeed, the Heisenberg principle has sometimes been highly praised as bringing moral responsibility back into the world.

On first hearing such arguments as to the dependence of a man's psychological behavior on the physical behavior of the atoms in his brain, one is tempted to continue the discussion at the physical level of abstraction. Thus, in the case of the classical argument, it is sometimes regarded as important to point out that the complexity of the atomic structure of the brain is so great that the possibility of predicting its behavior is a theoretical rather than a practical one. And in the case of the quantum argument, it might seem pertinent to point out that free will and moral responsibility could hardly be assisted by a principle which requires the undetermined part of atomic behavior to take place in accordance with the laws of random chance

On more mature reflection, however, it appears that both forms of the arguments as to the role of atomic behavior in the brain, in denying or in permitting free will, are based on a fallacious assumption that phenomena on the psychological level can be satisfactorily and completely treated on the physical level As pointed out clearly by Bohr, such arguments are really quite meaningless, since no experimental test would be feasible to determine whether the atoms in a man's brain are following either the classical or the quantum laws of mechanics when the man reports that he is acting with freedom of will The test itself would have to be so drastic as to destroy both the man's brain and the feeling of freedom of will which is an essential part of the experiment

I am very content with this clarification which Bohr has brought to one aspect of the old problem of free will and determinism, and wish to close with it as a final example of the usefulness of the concept of levels of abstraction. You will note that this example, with which I bring my simple remarks on the nature of science to their end, is one which emphasizes the circumstance that the discipline of physics, beloved and dignified though it be, is neither the whole of science nor the whole of philosophy. And with this conclusion, paying all due regard to my great affection and respect for physics, I find myself at peace.

BOOKS ON SCIENCE

GENETICAL EXPOSURE OF THE "RACE" MYTH[1]

A CONSIDERABLE flood of books on the subject of race in *Homo sapiens* has appeared in the last several years Some of these have come from the hands of sociologists and anthropologists, and at least once or twice a geneticist has couched his lance at the ugly head of the Nazi myth. If one recognizes a new spirit of knight-errantry in these efforts, of which the present volume is one of the most recent, it is nonetheless gratifying that not all of our knights cut the figure of a Don Quixote on a worn-out Rosinante, but that a number handle sharp and flashing weapons with considerable adroitness, and bestride fresh and vigorous chargers. Professor Dahlberg, in spite of translator Hogben's enthusiastic remark that he is "one of the six living people who know most about heredity," is not above revealing an occasional chink in his armor. Or perhaps this is but haste and carelessness on the part of Squire Sancho, who admits that he converted the book from the native tongue of its author in a brief fortnight of enforced delay in Sweden as he fled from the enemy then engaged in occupying neighboring Norway

This book, in brief, is not a comparison of the physical or cultural differences between so-called races, but is a consideration of those principles involved in race-formation. The first five chapters deal with standard genetic principles. Every geneticist will agree that a sound knowledge of these is essential to an understanding of the true nature of race Unfortunately, one is all too often left with the feeling that the relationship of the topics to the main theme is not made apparent. The author seems to drift into a presentation of a survey of genetics as a field of knowledge instead of providing a selection of those genetic principles that bear critically on the nature of races in man and of making that relation unmistakable.

The exposition is as a rule clear and simple, but the opening chapters particularly are marred by occasional statements or figures sure to be misleading and confusing to a lay reader. Some of these should perhaps be enumerated Any Drosophila worker would be surprised at the legend to Fig 16, where a normal fly with wings still unexpanded is said to represent the mutant "vestigial," while in addition two bristles always present in normal flies are said to be produced only through the action of the same mutant gene Figs 33 and 34 are hopelessly confusing They fit the text discussion very well, but the legends refer to crossing over between yellow body color and white eye color, which the figures were certainly never intended to illustrate, rather than to simple sex-linkage, which they do illustrate In the absence of any explanation, an inexperienced reader might easily be led to think the symbol *Y* stood for yellow body color, as *w* stands for white eye color, and that consequently yellow body color is limited to the male and transmitted by a chromosome limited to that sex On p. 114, the statement that "among intersexual females development at first goes in the male and afterwards in the female direction" is a confusing slip directly contradictory to Fig. 36 and the succeeding discussion Worker bees (sterile females) are said to be intersexes (p. 115)! The statement (p. 119) that "genes are chemical constituents which react with one another" is subject to grave misinterpretation, and the remark (p. 120) that "all genes which influence size and form may be said to

[1] ***Race, Reason and Rubbish.*** Gunnar Dahlberg. Translated by Lancelot Hogben. Illustrated. 240 pp. $2.25 November, 1942. Columbia University Press.

speed up or slow down cell division" is certainly far from true for either plants or animals An incomplete sentence at the top of p. 139 will undoubtedly make the reader scratch his head. On pp. 142 and 143 there are several mistakes in simple mathematics that will be obvious to those who already know how to calculate gene frequencies, but that may completely disconcert the uninitiated reader just skilfully introduced by Professor Dahlberg to the elements of population genetics. To correct any possible misimpression at once, however, let it be understood that these marks of carelessness and haste in the preparation of the manuscript do not, in the mind of this reviewer, keep the book from being an exceedingly valuable contribution to writings in this field

With Chapters V, on the relation of environment to gene exhibition, and VI, on the principle of random mating, the author gets fully into his subject The practical problem of determining the genetic portion of variability, of defining the limits within which "individuals with a particular gene equipment can vary under the influence of different external circumstances," to use his own words, comes up first. Genetic, environmental, and conditional characters are distinguished, and it is pointed out that there are no sharp boundaries between them

The relationship between the frequencies of dominant and recessive characters, on the one hand, and of the genes that differentiate them, on the other, is presented in a simple and graphic manner It is easy to appreciate the significance of such conclusions, as that as a recessive gene becomes rare, the proportion of individuals carrying the gene in a latent manner must increase in respect to those manifesting the character.

The effect of selection against undesirable characters is also treated graphically and without recourse to the mathematics that usually makes discussions of this subject difficult for the layman. One chart (p. 150), showing the frequency of a recessive character in successive generations when all recessives in each generation are prevented from having children, is worth volumes. The general conclusions are not very heartening to those eugenists who favor radical measures of sterilization or segregation, for while selection against common recessives would produce a rapid diminution in their frequency, there are practically no detrimental recessives that are common, that is, with a frequency above five per cent.; while on the other hand, adverse selection would have a wholly negligible effect on recessive characters that are rare, and most detrimental recessives are indeed rare To be sure, there are a few simple dominant conditions against which selection would be immediately effective, but over against these are numerous characters inherited in more complex ways, against which selection is even less effective in bringing about elimination than it is with simple recessives It is in any case comforting to know that if rare defects can not be stamped out, neither can advantageous characters that are rare and inherited in a complex fashion—high intelligence, for example

In considering the effect of inbreeding and assortative mating upon the incidence of inherited characters, the discussion is both clear and original The conclusion is that "if a recessive trait is common, a greater or smaller amount of inbreeding makes little difference to its occurrence . If it is extremely rare, inbreeding can greatly increase the occurrence of the character, but because the latter is extremely rare, a *relative* increase has no appreciable mass effect. . . In real life we may have to deal with large population groups. . . where really rare genes occur, but if so there are relatively few cousin marriages. . . . If we are concerned with a

small one, many cousin marriages occur, but in a small community no gene can remain really rare." "For the time being, in many quarters, inclination to apply the results of race biology in practical policy is too strong rather than too weak. People do not demand the certainty which they ought to seek before they undertake thorough-going reforms "

The three final chapters develop the concept of "isolates," groups within which marriage is more or less a matter of chance These may be geographical, but no less important are social, or class, isolates, and those of certain so-called "races," such as the Jews The average size of the isolate in western Europe is estimated at 500 potential mates per individual. Of course, isolates vary enormously in size, and are constantly in flux In Europe they have been breaking down and merging in recent times As a consequence, the frequency of rare recessive hereditary characters has considerably diminished. Although the responsible genes are themselves no less abundant than formerly, most of them are latent in normal (heterozygous) carriers On the other hand, characters that depend on the multiple action of dominant genes are enhanced by the break-up of isolates There is evidence that average stature has increased in Sweden from this reason, rather than, as is generally supposed, wholly from an improvement in standards of living Perhaps there is room for hope that intelligence may react similarly.

"Whatever may be said of isolates in general applies to races in particular " For inasmuch as "biologists do not speak of two races in nature unless each group actually has some territory where interbreeding does not occur appreciably, . . . a race . . . must be an isolate or group of isolates." Since migration and interbreeding have been so extensive in Europe, and since inherited characters show little or no correlation after a few generations of interbreeding, there is really no ground for assuming racial differences among European peoples. Europe has been as great a melting-pot of peoples as America It is quite as likely that any blond Nordic type is produced by segregation and recombination from a racial mixture as it is that there was ever a pure Nordic component of the mixture to start with

The chapter on the Jews is more than an apt illustration of the views of a geneticist on race It is an eloquent commentary on the prejudice equally of our own and of earlier times that ever seeks to clothe itself in the guise of the greatest moral or intellectual force of its day, whether that be religion or science

H B. GLASS

DESCRIPTIVE HUMAN PHYSIOLOGY[1]

This book is a tragedy It could have been, as the publisher's blurb says it is, without doubt, "the most easily comprehensible, the most complete, and the most fascinating work in its field ever offered to the general reader." Alas, one must add. it is dogmatic, inaccurate, superficial, in the way that the life sciences of the start of the century are superficial today, and often grossly misleading. There are hundreds of pictures, mostly beautiful and ingeneous ones. These are almost all that is claimed for them, except that they are a valuable contribution to biological teaching materials. But why did the author, who drew many with enormous pains and great skill, allow unnecessary errors and false implications to enter a number of them. In one on the metabolism of fat (p. 351), for example, the fatty acid molecule is represented as a watch chain of CH_2 links with a watch (CH_3) at one end and a small medallion (COOH) at the other. Why not make the polar group the big

[1] *Man in Structure and Function.* 2 volumes. Fritz Kahn. li + 742 pp. $10.00 April, 1943. Alfred A. Knopf

watch and the CH_3 the little medallion? But this is a picayune criticism. More serious. an enzyme, as a chisel, degrades the molecule by knocking out links—single links and from the middle of the chain. The drawing is excellent; the analogy, effective; the facts taught, half truths. It would have been as easy to tell the whole truth and have two links at a time knocked from the end It is this aura of positive half-truths that dims the book's value.

The pictures are, on the whole, excellent, and as descriptive anatomy the two volumes are useful It is man's function which is butchered—by the text Innumerable statements appear—flat unqualified factual pronouncements, often clothed in impressive quantitative garb—which must make any biologist squirm Here are a few examples from the first fifty pages. "Protoplasm is a chemical compound . "; "These salts [in protoplasm] have a large number of functions; for example, they conduct electric currents and are consequently the bearers of electrical energy in protoplasm"; "In the molecule of the blood pigment 16,669 atoms are united . ". "[Human chromosomes] certainly contain 10,000 times as many genes as those of the simple fruit fly . . ."; "For the generation of a human being 225 million sperm cells line up . . ."; "Through the terminal openings of the lymph-vessels flows the abdominal fluid, which moistens the pelvic organs . . "; "Each connective-tissue fibre in our skin is a minute but independent vital unit that 'wants' to breathe, eat, rest, and exercise daily in order to remain healthy " But they continue through the book: "an exhausted human being can be restored to full working efficiency immediately through the administration of fresh blood or the serum of a rested body." (p. 133); "Chlorophyll itself contains magnesium instead of iron, but it attracts iron compounds from the soil " (p. 212); "Amino acid $\times 3$ = peptone $\times 3$ = albumose $\times 3$ = protein." (p 286); ". . . the human body has hundreds, perhaps even thousands of nerve fibres, " (p. 471)

But even this is not the worst failing of the book. The presentation of human biology is, in the main, correct But it is dogmatic, barrenly categorical and descriptive, and written from the view-point of the physiology of thirty years ago with a few modern facts added The author gets almost poetic about the "profound internal laws of harmony" which regulate body proportions But his ponderous statement that the human body is a walking tower of three stories," the skull; in it live the organs of the outer germ layer, the brain and many of the sense organs . . the chest; here lives the central organ of the middle germ layer, the heart, together with the middle portion of the skeleton . the abdomen; in it resides the organ system of the inner germ layer, the digestive apparatus," irresistably reminds me of the school boy's famous essay on the same subject: "The body consists of the head, the chest, and the stomach The head contains the eyes, ears, nose, mouth, and brains, if any. The chest contains the heart, lungs, and part of the liver The stomach contains the bowels, of which there are five; a,e,i,o,u, and sometimes y and w."

The book will probably be a great success—lovely pictures, positive answers to the sort of questions laymen are wont to ask, an aggressive promotion—almost insure it But the lay reader will be entertained more than instructed. He will accumulate phrases and facts (not all correct) more than understanding and insight. As I wrote some years ago on science popularization, "The reader of such news items is only concerned, or at least the writer of them assumes he is concerned, with enjoying a gentle tingling of his imagination, a sort of mental Turkish bath. Active exercise of his intelligence, to appreciate the significance

of or principles behind a real scientific development, is neither expected nor aided."

"Man in Structure and Function" will not help to bring science to the people, only scientism: that is the tragedy, for the book has so much of excellence in it that it could have humanized a science and educated the people Instead it erupts dogmatic statements garnished with pretty pictures

R W GERARD

THE NATURE AND HISTORY OF HURRICANES[1]

IN the run of daily weather, we forget what great storms can do, and we are inclined to go about our daily tasks without thought of the dangers Mr Tannehill vividly, yet dispassionately, describes the winds and storm waves of hurricanes, the origins and tracks of West Indian hurricanes, the rainfalls and barometric pressures, the signs of approaching storms, unusual hurricane movements, and the frequency and destructive effects of these terrific storms The reader is then in a very receptive mood for the chapter on precautionary measures.

Following this, nearly half the book is devoted to a listing of 978 tropical storms known in American Atlantic waters since the time of Columbus, including maps of the tracks of all storms since 1901, and descriptions of the greater hurricanes. At the end, is a seven-page bibliography and a five-page index

This is the second edition, the first having been published in 1938, just before the great New England hurricane. It is partly because of this storm and the evident need for wider knowledge of the nature of hurricanes and of the need for adequate precautions against them in areas where storms have not struck for decades that the new edition was brought out so soon The main body of the text has been extended by about one page, to bring to date the part that radiosondes are playing (pp 9–10), and to summarize losses of life and property in the twenty-five years 1917–1941 (p 133) The losses of life are set at 4200 in the United States and in excess of 10,000 in the West Indian region, Central America and Mexico Property losses in the United States in these twenty-five years seem to have been of the order of half a billion dollars, more than fifty per cent of which was in the New England hurricane of 1938. An appendix of eight pages briefly summarizes the hurricanes of 1938–41, without, however, giving any references to detailed published discussions even of the meteorology of these storms. either here or in the bibliography, which includes no references to hurricane literature later than 1937 Minor defects in the first edition have unfortunately been mostly carried over into the second. For example, the wind map (Fig. 21), is credited to Bartholomew, the cartographer, rather than to Köppen, who compiled it On p. 47 it is stated that hurricanes develop just south of the Isthmus of Panama, when Tehuantepec is apparently meant. On Fig. 40, Adjuntas, P R, which the text, p. 70, states had 29 6 inches of rain in the hurricane of Sept 13–14, 1898, is shown as less than 25 inches

"Hurricanes" is an exciting book to read and it is valuable to keep for reference, especially if a hurricane threatens! Tannehill's treatment stands alone, as well it might, the author being chief of the Marine Division of the Weather Bureau and having had many years' experience as forecaster at Galveston, which after the greatest hurricane disaster in the history of the United States (in 1900) is now, "with its sturdily built buildings and its great seawall, . . . more strongly fortified against the tropical cyclone than any other city in the world."

CHARLES F. BROOKS

[1] *Hurricanes Their Nature and History.* Ivan R. Tannehill Second edition. Illustrated. x + 265 pp. $3.50. 1942. Princeton University Press.

NICOLAUS COPERNICUS, 1473–1543

THE PROGRESS OF SCIENCE

COPERNICUS AND THE HISTORY OF SCIENCE

THE life work of Copernicus culminated in his masterpiece, "The Revolution of the Heavenly Bodies" This astronomical publication performed a two-fold function in the History of Science: It undermined the old philosophical system of the world, which was earth centered and glorified man; it laid the foundation for a new scientific system of the physical universe, which enthroned nature as the final arbiter of natural law The doctrine that the earth and other planets revolve about the sun replaced the old geocentric system and originated the inductive period which culminated in Newton's law of universal gravitation, accepted at that time as the greatest scientific generalization of the human mind.

The apparent motion of the heavenly bodies had attracted the attention of all primitive races—the daily rising and setting of the sun, the monthly waxing and waning of the moon, the periodic advance, turning point and recession of the planets along the zodiac, the annual heliacal rising and setting of the constellations marking the return of the seasons The ancient royal astronomers of the practical Chinese observed the stars to determine the time for seed-time and harvest and to direct state affairs Ancient Sumerians, Indians and Egyptians added to the recorded observations and determined the periods of the recurrences of celestial phenomena

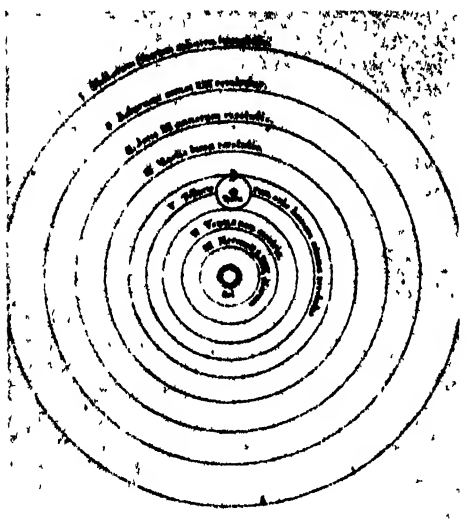
The Greek philosophers inherited the accumulated data of the ancients, and Plato proposed the problem of reducing celestial motions to mathematical law Some observations were added and the adopted solution was an immovable earth at the center of the universe The Pythagoreans proposed an imaginary central fire around which revolved the real bodies including the earth and an imaginary counter-earth Aristarchus, the ancient Copernicus, advocated a system with the sun at the center; but Aristotle and others, including Hipparchus and Ptolemy, accepted the geocentric doctrine Incorporated in the science, philosophy and religion of Europe, it survived the Dark Ages and played its part in the rise and decay of Scholasticism Intrenched in the early universities of the Renaissance, several of which Copernicus attended, and upheld by the authority of the church, the geocentric doctrine appeared invulnerable.

It took indomitable courage to propose a doctrine, patiently worked out through prolonged mathematical labor, which challenged the authority of the ages But the mind of man was expanding Printing presses multiplied and Columbus sailed beyond the known horizons The great life work of Copernicus at this opportune time changed the scientific outlook of the world and shook the foundations of philosophy and religion

It is said that Copernicus was accused by Kepler of interpreting Ptolemy, not nature We agree with the first, but hesitate to accept the latter part of the accusation It is true that Copernicus thoroughly understood all the details of the Ptolemaic system, even to the extent of applying the geometric method with modifications to explain his own heliocentric doctrine. We reject the insinuation, however, that Copernicus did not interpret nature He failed to obtain a complete solution of the problem of motion of the heavenly bodies, but to use Melanchthon's figure, "He stopped the sun and set the earth in motion." Furthermore, the physical universe with its unnumbered stars was interpreted by him as a larger and grander system than previously conceived by the mind of man. This conception followed the absence of observed annual parallax of the stars due to their very great distance. He

correctly interpreted the puzzling loops in the apparent paths of a planet as a combination of the real motions of the planet and the earth. His heliocentric doctrine overthrew the Ptolemaic system which interpreted "nature as she seems, not as she is."

Following the basic work of Copernicus, Tycho Brahe made systematic observations of planetary motions using improved instruments and methods, thus providing more accurate data for the solution of the age-long problem. Galileo applied the telescope in astronomy,



THE COPERNICAN SYSTEM

challenged the authority of Aristotle and established fundamental principles in dynamics, the science of motion Kepler abandoned the metaphysical idea of uniform circular motions and established his three empirical laws, based on the ellipse Newton, standing on the shoulders of these men, invented the essential method of the infinitesimal calculus, introduced the necessary concepts in physics, including mass, and succeeded in formulating the law of gravitation, the first great physical synthesis, which rationalized the empirical laws and gave a scientific solution of Plato's problem.

The motion of the perihelion of Mercury's orbit defied Newtonian gravitation but satisfactorily obeys the broader generalization of relativity proposed by Einstein. On the foundation provided by Copernicus, a Pole, the superstructure was built by a Dane, an Italian, a German, an Englishman and a Jew, who is now an American by choice.

The work of Copernicus caused a revolution in science that dealt a severe blow to the smug anthropocentric ideas of the sixteenth century Science, philosophy and religion had accorded man a position of self-imposed dignity at the center of a world of his own, created for his edification, real only as conceived by his transcendent mind When the immovable terrestrial foundation was removed from the center and set spinning around the sun, not merely was the outmoded natural philosophy of Aristotle left behind, but the authoritarian rationalized principles in moral philosophy, metaphysics and theology—man-made systems—were also left without a firm foundation The teleological explanation gradually gave way to a mechanistic interpretation of the universe, which was not favored by Newton himself, whose work completed the inductive period begun by Copernicus. The naive realism which followed, attributed perhaps wrongly to the physical scientists, dropped the transcendentalism, but was inclined to hold to the universality of its so-called laws of nature. In the nineteenth century biology proved that "natural laws" are not immutable by demonstrating the variability of species The new realism of the twentieth century, with data from the physical universe, based on the quantum, wave mechanics and Einstein's relativity, brings us again face to face with the motions of the heavenly bodies as a test of truth and reality. Thus four centuries after the death of Copernicus we build on the foundation he laid

W. Carl Rufus

EXHIBITS OF INDIAN LIFE BEFORE COLUMBUS

WITH the opening of the west section of a new hall in the Field Museum of Natural History (Chicago), a section called "Indian America," an era of radically improved technique in anthropological exhibits has been inaugurated Here the visitor will find to his delight that a few specimens with practically no labels, but with good lighting and a liberal use of gay colors harmoniously and tastefully blended, constitute irresistible displays All previous ideas and methods of displaying materials have been discarded Formerly, it was our wont to exhibit specimens—many baskets, hundreds of stone tools, rows of pots--with no attempt to give meaning to these objects Just as a series of nonsense syllables do not make a poem or the words in a dictionary do not constitute a story, so did these exhibits make little sense to anyone There are many museum curators who still cling to the notion that a drab case, full of spears or butterflies or rocks, is so tantalizingly attractive that the casual visitor will be compelled to look at the exhibit Experience has proved that such exhibitions do not teach anything

The scientific method, which includes observation as well as the recognition of realities, when applied to this antiquated notion of museum exhibits shows conclusively that the ordinary visitor will give no more than a hasty and bored glance at these "systematic" exhibits For the most part they tell no story, have little meaning, are dull, forbidding and fatiguing, and have been responsible for the common phrase, "Dead as a museum" The most that may kindly be said about the older systematic exhibits is that they are really study collections stored in public halls and useful only to a handful of specialists

The Department of Anthropology at the Field Museum has rejected these outworn methods and started to work out new methods of display which will teach the function and meaning of objects. The first practical application of these methods has been tried out in this hall which is to be devoted to Archaeology of the New World The first section of the hall was opened January 25, 1943

SYNOPSIS OF EARLY AMERICAN CULTURES

To set forth the archaeology of North, Central and South America in one hall may seem like a bold, almost impertinent, and impossible feat Yet we are confident that it can be done Of course, we shall attempt to present only the most essential facts concerning the history of the Indian civilizations, but this will be done in a comprehensive though necessarily synoptic fashion The purpose of this entire hall will be to give the visitor a bird's-eye view of the ancient cultures and civilizations of the Americas The accomplishments of the peoples of each large geographical area will be shown in relation to those of other areas It is proposed to emphasize modes of life rather than specific traits and developments The exhibits in the hall are designed to give in an integrated fashion a basic knowledge of New World archaeology to any interested visitor From this hall the visitor can then go to the other Indian exhibits in the Museum with a framework of knowledge, understanding and depth of perception which will give him greater insight and pleasure. It is the avowed purpose to increase the knowledge, happiness and experience of every visitor by stimulating thought and feeling.

There will be three sections in this new hall, when it is completed: (1) "Indian America," the New World civilizations as the White Man found them. This section is now completed and was opened on January 25, 1943

Field Museum of Natural History

MAYA NUMBERS, FREQUENTLY FOUND IN MAYA "FARMERS' ALMANACS"

Field Museum of Natural History

TYPES OF INDIAN HOUSES AND TEMPLES

AS THEY WERE BUILT IN DIFFERENT PARTS OF NORTH, CENTRAL AND SOUTH AMERICA.

(2) The New World civilizations as they were in the thousands of years preceding Columbus This section will exhibit the main accomplishments of the Peruvians, Mayas, Aztecs and Pueblos, as well as those of the Indians of the Mississippi Valley and the rest of North America. It will also show the chronological order and the sequence of these civilizations from approximately the year 1492 back to the earliest evidence of man in the New World—or about 15,000 to 25,000 years ago The task of presenting these subjects will be carried out by means of dioramas and a limited number of specimens tastefully arranged to illustrate use.

(3) Techniques: how stone, bone and metal tools, pottery, baskets and clothing were made and used, how archaeologists find, excavate and date ancient ruins; and, finally, how archaeologists collect and interpret information such as is assembled in Section 2

In Section 1 are shown some of the fundamental characteristics of New World civilizations and cultures as they were at the time when the White Man came. that is, at the point where recorded history and archaeology (unwritten history) meet. It is axiomatic that to exist, every man must eat, clothe himself, erect some form of shelter, and make and use tools—even though all of these homely and fundamental tasks be performed either on a relatively simple plane or in a complex way. These aspects of Indian life are exhibited in this section, not with reference to one isolated area, but with reference to the entire New World. Such fundamentals can best be considered in this way

Field Museum of Natural History

CLOTHING OF THE INDIANS OF NORTH AND CENTRAL AMERICA

The exhibits deal with a series of important culture traits arranged to show their forms and then spatial distribution over North, Central and South America. Specifically we take up the following subjects· (1) Where we obtain some of our knowledge concerning the customs of the Indians; (2) architecture (houses and temples); (3) travel and transport; (4) clothing; (5) decorative art; (6) economy—that is, agriculture, tobacco, hunting and fishing, seed and root gath-

Field Museum of Natural History

USE OF THE *BOLAS*

THE *bolas* (SPANISH FOR "BALLS") WAS USED BY THE NOMADIC INDIANS OF THE PATAGONIAN PLAINS TO CAPTURE THE GUANACO, A SPECIES OF WILD CAMEL, WHICH WAS THEIR CHIEF SOURCE OF FOOD. ONE BALL WAS HELD IN THE HAND AND THE WEAPON WAS WHIRLED ABOUT THE HEAD AND RELEASED IN THE DIRECTION OF THE ANIMAL. THE WHIRLING THRONGS CAUGHT ABOUT THE ANIMAL'S LEGS AND NECK, AND BROUGHT IT TO THE GROUND. THE INDIAN THEN KILLED IT WITH A CLUB

ering; (7) distribution of types of basketry, pottery, weaving and textiles, and metal work; (8) a chart showing why some Indian civilizations are rated higher than others, and (9) writing

These newly opened exhibits are really an example of the way archaeological knowledge is built up The procedure which has proved most useful is that of working from the historically recorded known back into the past The starting point for investigation is where recorded history—as left by conquerors, explorers and missionaries—and the unknown (prehistory) meet This is the point whence archaeologists begin their "backward research" The visitor is shown the final and some of the greatest advances made by the Indians before the coming of the Whites From this scene, one will (when the next section is ready) journey backward into prehistoric times and will obtain glimpses of what was happening in various New World areas, at say, A D 1200, 1100, 1000, 900, 800, and finally 20,000 B C

PAUL S MARTIN

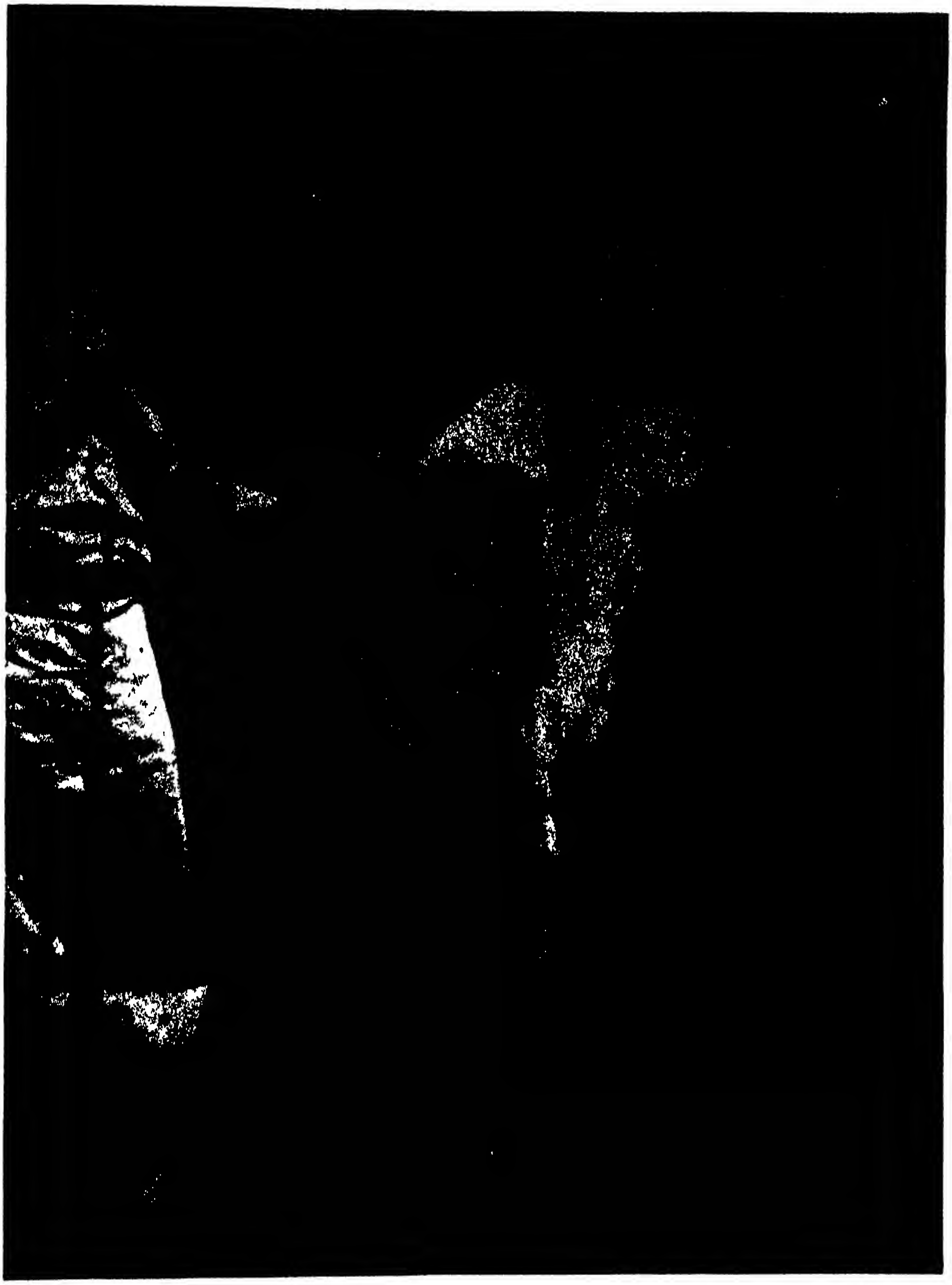
FRESH-WATER SHARKS OF NICARAGUA

HARVARD UNIVERSITY ichthyologists are jubilant over the arrival of the only known fresh-water shark in the world He is *Carcharinus nicaraguensis*, caught after a series of tribulations, in the tepid waters of Lake Nicaragua in the Latin American republic. Although Harvard has not yet solved the problem of how the shark shook off his salt water habits, perhaps many thousands of years ago, and took to the fresh water of the lake, it has been proved, for the first time, that the creature came from the Atlantic rather than the Pacific side of Central America

The weazened remains of the Nicaragua shark rest in the basement of the University Museum, an unappetizing sight for the layman but a choice morsel for those scientists who devote their lives to the study of rare fish

Harvard's efforts to obtain a specimen of *Carcharinus nicaraguensis* started a year ago Through the cooperation of the Carnegie Institution, which had archaeologists working near the lake, a shark was snagged out of its waters. With due ceremony, it was placed aboard a schooner, in a barrel of salt, for the first leg of shipment to Cambridge A submarine without a sense of humor spotted the schooner and sank it *Carcharinus nicaraguensis*, quite irretrievable, thus returned to the salty habitat of its ancestors and sank to the bottom with the ship.

Dr. Thomas Barbour, director of the University Museum, and Dr. Henry B.



ONLY SPECIES OF FRESH-WATER SHARK IN THE WORLD
Carcharinus nicaraguensis, WHICH HAS JUST BEEN RECEIVED AT THE UNIVERSITY MUSEUM AT HARVARD UNIVERSITY. IT WAS CAUGHT IN LAKE NICARAGUA IN LATIN AMERICA BY MAJOR CHARLES M. DUKE, AN AMERICAN ARMY ENGINEER.

Bigelow, professor of zoology, who finally identified "C.N." as of Atlantic origin, renewed their efforts to get a specimen to Cambridge. They had heard that Sweden, many years ago, obtained one, and they knew that a specimen which was on show in Washington in the gay '90's had disappeared. Unless it was being kept under cover *Carcharinus nicaraguensis* was not represented in this country, dead or alive.

An appeal was addressed to President Anastasio Somoza of Nicaragua. An ardent angler, the President went fishing several months ago and dragged not only one but three sharks out of the lake. Photographs of the event were taken and sent to Cambridge. Harvard fish experts took new heart. But facilities for shipping the sharks here were lacking, because of the war, and the President was left with nothing but pictures to show for his prowess.

Finally, last February, an American army engineer, Major Charles M. Duke, joined the Harvard hunt and caught the shark now in the University Museum. The creature, when taken out of the water, was about five feet long. The fresh-water sharks of the lake have been rumored to reach the length of ten feet. They have the nasty habits of their salt water relatives and are considered dangerous even by the Nicaraguan natives.

In the '70's, these fresh-water sharks were discovered. Theodore Gill, famous Smithsonian ichthyologist, obtained one and gave it the family name, in honor of Nicaragua.

However, according to Dr. Bigelow of Harvard's museum, this variety of shark was never compared with salt-water sharks to determine whether its original family habitat was the Atlantic or Pacific Ocean.

"It is apparently of Atlantic origin," said Dr. Bigelow. "When it got into the lake we can not say. It might have been centuries ago. How it got in is more of a mystery. A river, going down to the sea from the lake, has such steep descents and swift rapids that I don't believe a shark could swim up to the lake. The presence of these fish may be due to convulsions of nature, such as a volcanic eruption, which aeons ago changed the conformation of the land.

"Amazingly enough, the fresh-water shark has changed very little from the salt-water shark of the Atlantic coast of Nicaragua during its residence in the lake. The shape of the mouth and the relative position of the fins show the only differences." H. U.

THE ETHNOGEOGRAPHIC BOARD

THE armed forces and other government war agencies are constantly in need of securing rapidly authoritative detailed information upon regions in all parts of the world which are now, or may in the future, be of strategic importance. Yet no comprehensive means exists in the government for establishing direct contact with the best qualified individuals and groups, regardless of profession, to furnish such data. On the other hand many scholars and scientists possess the information the government needs, but are not always acquainted sufficiently with the government agencies to be able to place these data in the hands of the official who most needs them. The Ethnogeographic Board was established in June, 1942, as a clearing house through which the various government agencies and the scholars and the scientists of the country could be brought together more rapidly and effectively to solve questions relating to world regions.

The Ethnogeographic Board is sponsored by the National Research Council, the American Council of Learned Societies, the Social Science Research Council and the Smithsonian Institution. The last of these has graciously provided office space and facilities in the Smithsonian Institution Building and

DR. WM DUNCAN STRONG, DIRECTOR OF THE ETHNOGEOGRAPHIC BOARD
SEATED AT HIS DESK IN THE OFFICE OF THE BOARD IN THE SMITHSONIAN INSTITUTION

permitted several of the staff members to devote practically full time to assisting the Board in its work Early this year generous grants from the Rockefeller Foundation and the Carnegie Corporation have insured the effective continuance of the Board's activities for many months to come

Two conceptions are fundamental to the Board's activities In the first place it is a non-governmental agency established in the name of the scientists and scholars of the country for the purpose of aiding the government. In the second place, because its primary interest lies in many regions of the world, it is interdisciplinary in scope, seeking to use the facilities and knowledge of the earth sciences, the biological sciences, the social sciences and the humanities, in so far as these relate to regions outside of the continental United States

The Director of the Board is Dr Wm Duncan Strong, professor of anthropology, on leave from Columbia University. The membership of the Board was selected jointly by the four sponsoring organizations on the basis of the individuals' competence in their respective disciplines and their familiarity with major world regions The present membership of the Board is as follows· Wendell C Bennett, Carter Goodrich, John E Graf, Mortimer Graves, Carl E Guthe, Chairman, Robert B Hall, Wilbur A Sawyer and Douglas M Whitaker

Associated with Dr Strong in carrying forward the activities of the Washington office is a group of individuals who have been appointed as need for their services has arisen It is anticipated that additions to this group will be made as required

By demonstrating the usefulness of the Board's facilities, Dr Strong has established official liaison relations with the Army, the Navy, the Office of Strategic Services, and informal but equally effective relations with a large number of other government agencies, including the Board of Economic Warfare, the State Department, the Department of Agriculture, the Office of the Coordinator of Inter-American Affairs,

PORTRAITS OF THREE SECRETARIES OF THE SMITHSONIAN INSTITUTION
ON THE LEFT IS SAMUEL PIERPONT LANGLEY, A PHYSICIST AND ASTRONOMER WHO FIRST DEMONSTRATED THE PRACTICABILITY OF MECHANICAL FLIGHT, IN THE CENTER IS DR CHARLES G. ABBOT, AN ASTROPHYSICIST WHOSE MAIN RESEARCH IS IN SOLAR RADIATION—THE PRESENT SECRETARY OF THE INSTITUTION, ON THE RIGHT IS CHARLES DOOLITTLE WALCOTT, A GEOLOGIST WHOSE WORK WAS DEVOTED MAINLY TO CAMBRIAN PALEONTOLOGY.

the Office of Foreign Rehabilitation and Relief Operations, and others

The types of inquiries received from the several government agencies fall into four major classes. The first of these is for informal "spot" information, which can usually be secured within not more than one or two hours The second is for data upon individuals or groups or upon some specific regional question which may require a day or two of searching A third is for infomation which requires some compilation and study by qualified experts, resulting in a manuscript report which can usually be completed within a week or so. The fourth requires the organization of a project to be undertaken by an individual or organization which will result in a formal report at the end of several months All but the first type of these requests are usually received as written directives from the proper government officials

In order to meet the inquiries concerning competent personnel the Board has established a file arranged by areas containing detailed information about competent individuals who have visited particular regions. This includes their specific fields of interest, their experience in the field, and the nature of the data, including maps and photographs which they possess In establishing these personnel lists the Board has drawn upon the lists prepared by various committees of the sponsoring organizations, the facilities of the National Roster of Scientific and Specialized Personnel, and the lists made available to it by some

government agencies and some civilian organizations

In answering the inquiries from government agencies relating to conditions in particular regions, the Board uses the many facilities of the sponsoring organizations, and through them those of the divisions and affiliated societies with which the sponsors are associated. Dr. Strong's relations with many different government agencies also enable the Board to arrange for the exchange of pertinent information between government agencies as occasion arises

Because of Dr. Strong's knowledge of the interests and activities of the government agencies, the Ethnogeographic Board is able to render a distinct service to the scholars and scientists of the country. It is in a position to place committees of scholarly organizations in touch with the appropriate officials of government agencies, and also to advise individual scientists and scholars visiting Washington concerning procedures they should follow in establishing proper government contacts. In addition, the Board has sponsored a series of conferences in Washington upon regional problems to which are invited scholars and scientists in government service, thereby bringing about exchanges of opinion among professional men working in various government agencies.

It must be recognized, of course, that the many government war agencies possess a variety of means of securing information upon strategic regions. Therefore the Ethnogeographic Board is not used by these agencies to secure routine information, but rather is called upon concerning subjects which the several agencies are unable to clarify through other channels available to them. Accordingly, the Board has expanded its activities in relation to the types of requests which have been received. These activities have been increasing in scope and expanding in terms of the regions covered. It is expected that the Board will continue to call upon additional sources of information as the demands made upon it by the Government agencies increase in scope

The reception accorded the Ethnogeographic Board by the government agencies and the cooperation received from scholars and scientists and their organizations throughout the country have amply demonstrated that the Board is filling a definite need and performing a useful service during this time of emergency. The office of the Board is establishing a "back-log" of information and sources of information which will make its services cumulatively more valuable. For obvious reasons immediate war needs receive first consideration, but various projects concerning post-war problems are also being prosecuted. Inquiries and suggestions from individuals and organizations in the scholarly and scientific world are invited.

Carl E. Guthe,
Chairman, Ethnogeographic Board

AN EXAMPLE OF FUSION OF SOIL BY AN ELECTRIC ARC

During a lightning flash the potential difference may be of the order of 1,000,000 volts, the current produced ranging from a few thousand to 100,000 amperes. This energy may be released in an interval ranging from .0002 second up to perhaps 1 second in a multiple discharge, when successive flashes occur along the same path. During severe thunderstorms in rugged regions, lightning frequently strikes at high points, sometimes fusing the rock. There are on record instances where lightning, striking into sandy formations, has produced long, branching, tubular fused structures, called fulgurites. These fulgurites are often several feet long but seldom more than two inches in diameter

MASS PRODUCED BY FUSION OF TOP-SOIL BY AN ELECTRIC ARC

During a violent thunderstorm near Wooster, Ohio, on May 30, 1942, an interesting and spectacular thing happened. A three-phase, 60-cycle transmission line carrying 22,000 volts was struck by lightning. The field wire, about the diameter of a lead pencil, was severed at the insulator and one end dropped to the ground on the field below. The current continued to flow through the wet soil, and for a distance of 45 feet, where the wire touched the ground, a series of electric arcs was produced, developing tremendously high temperatures. The great heat produced and the annoying glare of the arcs made it difficult for linemen to get near the wire. The wire was severed at 12:18 P.M., but the location of the break was not discovered until 3 o'clock. During this interval, at the point of the arcs the soil was fused into molten masses of slag which were left lying parallel with the wire for a distance estimated at 45 feet. The molten masses cooled into round, elongate bodies, having the shape of the trunk of a tree, with branches extending out to a foot in distance and the ground was baked to a distance of a foot. A mass of fused material, 18 inches long and four inches in diameter, was removed and is shown in the photograph. Four fragile branches about an inch in diameter were broken off during the process of removal.

The material is glassy and very vesicular, showing that the soil was fused. The vesicles are explained by the steam that was formed from the water in the soil. Some of the vesicles are more than two inches in diameter and as much as five inches long, with a tendency to be hollow in their centers although the openings are not continuous like the interior of a tube.

The soil in this region is glacial in origin, containing a variety of rock material such as clay, quartz grains, fragments and particles of limestone and sandstone, iron oxide, humus, and occasional rocks classified as glacial erratics. It can reasonably be inferred that the unusual body produced by the electric current fusion of top-soil was formed in the same manner as fulgurites and possesses the same characteristics.

KARL VER STEEG

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WHAT WE DO KNOW ABOUT RACE

By Dr. ROBERT REDFIELD

PROFESSOR OF ANTHROPOLOGY, THE UNIVERSITY OF CHICAGO

THE physical characteristics used by anthropologists to classify people racially have, so far as we know, practically no significance for cultural achievement. We can not validly say that skin color, hair form and other racial differences, of themselves and without reference to the attention paid to them, are of any consequence in human behavior. If we were to take no notice of the shape of the nose, we could not say that people with noses of one shape would not be just as well prepared to run governments or to write books as people with noses of another shape. We have no reason to conclude that the lips of Negroes are not as good instruments as other kinds of lips for speaking beautiful French or perfect English, as well as excellent Bantu. The brains of Chinese, African and North European are boxed in bony containers that differ somewhat in their characteristic shapes, but we have no real evidence that, on the average, the brains contained in the skulls of representatives of one of these racial groups are better organs for thinking than those occupying the skulls of representatives of the other groups.

What we do know to be important about race is known about the races that people see and recognize, or believe to exist. Physical anthropologists are concerned with race as a biological phenomenon. In this paper we are concerned with race as a social phenomenon. We might speak of the "socially supposed races." Such races have a reality, too, but it is different from the reality of biological races. If people took special notice of red automobiles, were attracted to or repelled by the color of red automobiles, and believed that the redness of automobiles was connected inseparably with their mechanical effectiveness, then red automobiles would constitute a real and important category. It is something like that with the socially supposed races. The real differences among biologically different groups may have little consequences for the affairs of men. The believed-in differences, and the visible differences of which notice is taken, do have consequence for the affairs of men. This is what we know about race. It is on the level of habit, custom, sentiment and attitude that race, as a matter of practical significance, is to be understood. Race is, so to speak, a human invention.

The biological differences which enable us to classify the human species into races are superficial differences. There are few racial differences deep inside our bodies. Racial differences are mostly in the outermost layer. This fact is important for the social significance of race, because, being in the outermost layer, racial differences are easily visible. It is skin color, hair form, the shape of the nose, the lips and the eyelids that enter into our awareness and become con-

nected with attitudes and judgments. The relative flatness of the shin bone has been used as a criterion in the biological classification of races. But there is no prejudice against flat-shinned races as such, because nobody, except perhaps a few anthropologists, know they exist. The visible racial characteristics constitute a marker, a label, for all to read. When the label has not been put there by nature, and if the identification of the group has become important in the thinking of people, there is a disposition to exaggerate it or even to manufacture it. When one drop of African blood makes a Negro, it may be believed advisable to look at the fingernails or the whites of the eyes of an individual to discover to which racial category he belongs. The anthropologists tell us that the Jews are not a race They are not a biological race because the people known as Jews are not enough like each other and are too much like other people to be distinguishable from them But as people act with reference to Jews, and to some extent connect the attitudes they have about them with real or imagined biological characteristics, they are a socially supposed race As such, they lack a clear and consistent natural label The Nazis require them to wear yellow arm bands or the Star of David. A cartoon stereotype of the Jew has comparable effect

It is the association of some such label with cultural differences and in combination with real or imagined biological differences that brings about a socially supposed race The observable physical difference is alone not enough. Red-haired people are not collectively noticed and judged any more than are red automobiles. They do not constitute a cultural group. But Negroes are, or have been, a cultural group, and the same is true of Chinese and Japanese, Italians, Jews and Swedes and, indeed, of lawyers, gangsters and professors. These are in varying degrees cultural groups, but in the cases of those named toward the end of this list there is little or no physical label, and much less disposition to identify the cultural difference with real or supposed biological difference So lawyers, gangsters and professors, whatever else they may be, are not socially supposed races.

In the Negro, the Chinese, the Jew and the White Gentile, the apparent marks of difference become identified with the sentiments and collective judgments that are held about these groups. In the first place these visible markers serve to assign a marked individual to the class to which others feel he belongs or to which he feels he belongs If members of my group look down upon Negroes, then any person with a black skin is recognized as one to be looked down upon. In the second place the racial labels and the biological differences which are believed to lie in, or be connected with, these labels become the reasons and the supposed proofs of the sentiments and judgments borne toward the marked group When the rise of the cotton industry induced Southern leaders before the Civil War to stop apologizing for slavery and to begin defending it, it was asserted that the Negro lacked the native intelligence to be more than a slave. It was said that the low skull of the Negro pressed upon his brain and prevented him from becoming intelligent

It was not, of course, the Negro's skull that pressed upon him It was slavery and ignorance that pressed upon him. But the skull got the blame The skulls always do When people have prejudices it is convenient to support them by referring to the will of God or the wisdom of science The latter is as innocent as the former The beliefs of people about the physical features of race become a sort of false science Or we might call them a modern mythology. We believe many things about people who are dif-

ferent from ourselves, many of which are not true It is not now widely believed in this country that Jews perform ritual murder; the belief that they control the present Federal Government or American business is more commonly encountered. In so far as the Jews are thought of racially, these are beliefs as to race, and so relevant to our discussion.

We now review some of the things that we do know to be important about race. We do know that the cultural differences between groups come to be associated with noticed and imagined physical differences and that sometimes the latter are regarded as the explanation of the former We learn that this happens and something about how it happens from the history of race relations The racial explanation of cultural differences has great antiquity and has followed a varying career In a great many societies where groups looking and acting differently have dwelt together, the differences between them and the kinds of relationships established between them have been explained racially. They are also often commonly justified racially Greek writers offered a justification in racial terms for the subordination of helots to Athenian citizens. Negro slavery and discrimination against Negroes have been regularly supported by similar argument The doctrine of a master race, capable of ruling and of creation, as contrasted with lesser breeds, such as Poles and Jews, capable only by being ruled and of imitating and obeying, was developed by a number of nineteenth-century writers By the Nazis it has been elevated to a cardinal dogma and a principle of statecraft. At present, in this country, the Japanese, who used to be regarded as a wonderful little people, are being radically reinterpreted. Our enemies, they tend also to be set away so far from us racially that it seems as if now they had connection with us hardly humanly at all but only as co-members of the Animal Kingdom.

We are saying that the social significance of race, which is its only practical significance, is a product of history. It results from the interaction of human nature with situations of group difference and group relationship. It is not always the same It does not even always exist.

For the small child there is, characteristically, no significance in race. There is surely no instinct of racial prejudice or of racial recognition Children brought up in societies where there are racial prejudices ordinarily begin to share them—or perhaps to rebel against them—at the age when self-consciousness begins In the first years they exhibit no special sort of behavior toward representatives of other races. They may not even pay much attention to the physical differences A small White child drawing a picture of the Negro cook in the kitchen, may run into the kitchen to see whether her black friend's eyes are blue or brown It is clear that attitudes about racial groups have to be learned.

When racial groups come into contact with each other for the first time, it does not always follow that they at once dislike each other. Certainly, under such circumstances, they do not at once pronounce judgment as to the worth or character of each other The white skin of the European was interesting to the Indian and to the African when first seen. It drew the native to look further into these odd-looking invaders In some cases the appearance of the newcomer was found to be fearful, and the native fled Physical difference, within limits, attracts, else the exotic would not be appreciated. The first Negroes brought to Europe by White explorers of Africa were welcomed into intimate household association with aristocratic Englishmen; they were interesting oddities. It

took time for the attitude of the North European toward the black man to develop its characteristic form.

The dependence of racial attitudes upon historical events is likewise shown by the varying course of these changing attitudes with regard to any one racial group. The American Indian has passed through an almost complete cycle of collective judgment: he has been the Noble Red Man, that "varmint," good only when dead, and that appreciated and interesting fellow-American whose blood in one's veins is considered desirable rather than otherwise. I have mentioned the case of the Japanese, the vermin of the present year. It is humbling to a lesser student of race relations to read what one of our greatest sociologists and students of race relations wrote about the Japanese in 1905: "It is indeed probable that in the event of a successful struggle with Russia, little will remain of prejudice against [the Japanese] this smallish, yellow people, or of impediment to social and matrimonial, as well as political and commercial, association with it."[1]

Let it be said again that what we do know about race is that it is significant as account is taken of it at any time and place, and that the significance changes as the time and the place change. In some interracial situations peoples come together freshly; neither has a traditional view of the other; then the character of race relations will be determined largely by immediate circumstances. So it was that some Indian tribes welcomed the White man and regarded him favorably; others sought to destroy him. In such a situation the whole difference could be determined by one gift or one bullet. On the other hand, some interracial situations are the product of long histories, and new events can only modify, one way or the other, the character of those relations. The situation of the Jew is of this sort. He has been so long an international scapegoat that in any new situation that requires a scapegoat he is likely to be the unfortunate candidate.

It follows that the factor of race—the visible marker with its assumed implications as to inherent difference—gets itself attached to groups that are separated or segregated or stigmatized. As people think and feel themselves different from, or better than, other people, and there is a racial marker, so there arises a race-relations problem. In the case of the Chinese on the Pacific Coast, in the early days of anti-Asiatic sentiment, there was an association of a racial marker with an economically conflicting cultural group. The Japanese today is at once the enemy with whom we have come to closest grips and also the wearer of a face notably different from our own. The influence of the racial marker may be so strong as to overcome even the knowledge gained by personal acquaintance with members of the racial group. To cite one example I mention the situation of many young American citizens of Japanese descent who are today confined in relocation centers. In one of these centers an American of, I think, Swedish descent was employed as a garage foreman in charge of six or seven mechanics. Finally he gave up the job after trying for weeks to be happy in it. "It's no use," he said; I look at them and I can't help thinking of them as Japs." He meant, of course, as our Japanese enemies on the other side of the lines on Guadalcanal. Yet his mechanics were boys born and brought up in Oakland and Los Angeles and educated in our schools. Had they looked like his own sons, the foreman would have got along with them, and would, probably, have forgotten the fact that they had enemy-alien parents.

The effectiveness of race as an indicator of the relations between groups is

[1] W. I. Thomas, *American Journal of Sociology*, 91: 608–9.

probably greatest where it indicates higher and lower social status. When there are castes within a society, and the one caste is racially different from the others, then race is of greatest social consequence. The whole system depends on it. Our Old South is the most familiar example of this situation. In that society the fundamental castes are social castes. The significance of race is to identify the members of the two castes and to keep the one below the other. Negro and White may have close personal relations White and Negro may be linked in intimate sympathetic association. A White child caresses his Negro mammy. But the black skin, the conception of one drop of Negro blood, and a great many secondary indicators of the subordinated racial group serve to keep the castes sharply separated in terms of "aboveness" and "belowness" It is all right for Negro and White to be close together provided that the one is, without doubt, below the other. Hence come such Southern usages as the separation of Whites and Blacks at a lunch counter by a single symbolic vertical brass pole, or the practice of certain Southern banks to send out monthly statements of account to all White customers with the name at the head of the sheet prefixed with "Mr" or "Mrs," while the bank statements of Negro customers are made up without this designation.

In the North, on the other hand, and to a growing extent in the South, racial markers are not so clearly arrangements for the maintenance of caste lines Negroes have education and enter the professions, and the intimate families and small communities of both Negroes and Whites give way to looser and more impersonal communities So the Negro and the White drift apart from each other as the Negro to some degree gets out from under the White. The Negro and the White do not look directly up and directly down at each other; they come, almost, to look across at each other. Race is still important, but it serves to mark separation more and subordination less. So it is sometimes said that there is more race prejudice in the North than in the South. By this is meant that in the North the Negro is kept away from the White by the factor of race Human relations between the two groups are restricted by the difference of color. A man is prejudged as unworthy, or as merely inappropriate, to associate with because he is a Negro In the Old South the individual Negro was treated humanly just because he did not compete with the White for status. But when and if, in the South, he did or does challenge the status position of the White man, the response of the White man was or is correspondingly vigorous.

It is an understatement to admit that these few remarks about our own outstanding race-relations situation are inadequate to the topic. They are a few syllables muttered before a sphinx. Nevertheless it is easier to say something responsible, even though far inadequate, about Negro-White relations than it is to describe anti-Semitism under the heading, "What We Do Know About Race" What we do know about race in connection with the Jew is that race has played only one part in a long drama with many other actors Antipathy against the Jews is ancient; the identification of the Jews in racial terms, and the justification of anti-Judaism by reference to supposed biological fact, has entered into the problem at some times and in some places To see that fact is itself helpful in dealing with the problem

Antipathy against the Jew existed in the Roman Empire before Christianity; therefore the antithesis between Christian and Jew is not a necessary condition of anti-Judaism. In the Middle Ages there were important economic fac-

tors in the position of the Jew as trader and money-lender; and the religious justification for anti-Judaism was very great. Indeed, it is only with the decline of religious differences as the principal factors dividing man from his brother that in modern times the case against the Jew has been stated as a matter of race. It was in large part the students of language who gave impetus to the idea. They imagined a homogeneous Aryan people, to be thought of in contrast with the Semitic peoples. This provided a basis for the recent racial nonsense about Aryan and Jew The idea has its geography as well as its history. It was a German who in 1870 wrote that "civilization will overcome the antipathy against the Israelite who merely professes another religion, but never against the racially different Jew," and it has been chiefly Germans who have spread the doctrine of racial difference between Jew and Gentile—especially the so-called Aryan Gentile In old Russia antipathy against the Jew rested much more on difference of religion, custom and occupation than it did upon race Perhaps this is one reason why, under the Soviet régime, when religion was removed or subordinated as a difference between men, and the social doctrine called for economic leveling, anti-Judaism and indeed racial prejudices of all sorts have been so much reduced

At any rate the difference between the case of the Negro and that of the Jew is apparent The conventional antipathies against the Negro have short historical roots; and the racial factor entered immediately and has always played an important part. The conventional antipathies against the Jew are outgrowths of prejudices of very great antiquity; and in their variations race has played a much smaller and a more local part. The Jew has long been the universal stranger. As a representative of his traditional religion, he has also been a convenient adversary for militant Christians, and, fairly recently he became, so to speak, a race. It is grim humor to say that the change in status is not a promotion. When one thinks of the massacre of St. Bartholomew and the excesses of the Reign of Terror, one remembers that man may do his worst against man in the name of religion or in the name of economic and political liberty Yet there is something about the allegation of racial differences that gives a powerful impetus to prejudice. If it is felt that the differences lie in biological nature, then the firing squad and the concentration camp find a terrible false justification as instruments of eugenics.

The cases of the Jew and the Negro, different as they are, have points of resemblance which suggest another item of knowledge that we do have about race. In the case of both Negro and Jew the two different racial groups, or the two different groups thought of as different racially, meet within the confines of our nation. Moreover, they meet within the confines of nations other than ours. In neither case do we find all Negroes in one national state, or all Jews, or all White Gentiles This fact is no doubt connected with the fact that there is a Negro problem and that we have anti-Semitism. Race relations are most difficult when the representatives of the racial groups meet within a single state and within many states.

This might be stated in terms of racial frontiers Where racial frontiers correspond with national frontiers and with natural geographic barriers, interracial problems are simplest. Then diplomatic representatives can act for each group, communications can be controlled, and adjustments can be made without much friction. When Japan was opened to the Western world by Perry, the Pacific Ocean marked the frontier between the two racial groups, and the relations of

the two peoples were managed by diplomacy without conflict

But Japanese came to this country, and Americans went to Japan. The frontiers between the two racial groups came to fall within the respective countries. Now formal representation between governments could no longer speak for the racial groups. Individual Japanese knew individual Americans, and the relations between the two groups were complicated by personal relations as well as by business relations Especially does the racial frontier become difficult and dangerous where problems of status rise to prominence The Negro problem was simple when first-generation Africans were concerned, for such Negroes had no part in the struggle for status It is the changes which take place, or threaten to take place, in the status of the Negro in our society which make the problem acute It was when Japanese settled in our country, when Japanese having lived here returned to Japan, and when the number of Caucasians in Japan increased that the Oriental-Occidental problem became complicated with matters of status, and so became grave. The anti-Asiatic exclusion and anti-citizenship laws were legislative expressions of a disposition on the part of our people to draw a frontier within a country shared now by Orientals as well as Occidentals But the racial frontier drawn by custom or law within a state has always to be defended, and defense of it involves conflict and often bitterness

The apparently irreversible course of civilization is continually complicating the racial frontiers. Populations increase at unequal rates Industrial development expands from centers of beginning and overflows marginal areas. Political growth is likewise expansive and takes the various forms of imperialism and colonialism. All these events tend to break down a situation in which the racial frontier is the same as the geographic frontier and the same as the frontier of the state Races meet within the nation, within the community, even within the family. Racial problems become internal.

As they become internal, they become connected with internal issues The racial factor, having been merely one of the aspects of difference between independent states, becomes an aspect of differences between political groups. Where representatives of different racial groups share the local community, everyone, in his ordinary daily conduct, approves or challenges the now internal racial frontier No matter what one thinks of anti-Semitism, one may find himself in an apartment building which excludes Jews, and every day the White man gives tacit assent to discrimination against the Negro Political parties and political sectarian movements seize upon the racial issue for its power to align men against each other, and the worst and the best of national leaders find themselves involved in racial issues

As racial problems become internal in many countries, so also they become international Communications between representatives of the same racial group in distant lands increase, and with it consciousness of race The problems of the East Indian become matters of concern to the American Negro. The Japanese propagandist appeals to the American Negro, claiming that this is a race war and that in spite of national alignments Harlem and Tokyo are on the same side, the victims of the White man's domination. So it is that the internal racial frontiers of many different countries tend to merge, in the global minds of modern men, into one or a few great racial frontiers. The problem of civil rights for the Negro, the problem of extraterritoriality in China, and the problem of the British in India, problems which once appeared local and separate, now come to be interdependent

These facts are all illustrations of the generalization offered in the beginning of this article. It is the noticed and the believed-in differences of race that are of consequence to men Race consciousness, race prejudice and race relations of all kinds are aspects of the peculiar nature of man It is because men have imaginations, because they develop conventional view-points, because they depend on such symbols as skin color, language, religion or surname as the short and easy guides to the expression of established attitudes that race is one of the principal factors in human affairs. Race is, therefore, a variable that depends upon custom and changes with historical event Therefore, in turn, it may be darkened by propaganda or it may be clarified by education

No one is needed to demonstrate that the attitudes men have about race run often against their own interests. The people of this country are determined to win this war It is clearly to their interest to win it. As clearly it is against their interest to prevent the utilization of our human resources in the most effective way possible Yet White men stop work in war industries because Negroes are employed to work beside them, and the best man for a wartime position may be passed over because he is a Jew. The Chinese or the Philippine resident of our country may be drafted for service overseas in our American army, but he may not ask to become a naturalized citizen. A Black man may fight for the country he shares with White men, but I do not expect to live long enough to see one do so in the uniform of a United States naval officer.

In the face of facts like these one hesitates to suppose that a mere statement of these matters will remove prejudice. To say that the significance of race may be clarified by education and research is only to say that understanding of the matter may by these means be improved. Education and research with regard to race are increasing. It is not clear that race prejudice is decreasing. From this one may not conclude that education and investigation are to be abandoned, but only that changes in racial attitudes follow from influences which, at the present time at least, are stronger than education and science.

While our attention is upon race prejudice, that form of race relations which most obviously makes for difficulty and for pain in the efforts men exert to live with one another, it may be noted that race prejudice has a curious and a mixed history in its relation to social doctrines that do not depend on race One might think that a great equalitarian cause would always destroy race prejudice. But apparently such a doctrine does not always do so. There have been cases where a great cause has swept aside inconsistent racial doctrines, and there are cases where such a cause has failed to do so, while yet remaining a great cause. The Mohammedan religion took within it all colors and racial groups, with little discrimination Perhaps this was because Mohammedanism excluded the non-Moslem from the brotherhood of man. Christianity, on the whole and with conspicuous exceptions, has not been as hard on the non-Christian, but racial discrimination flourishes in so-called Christian countries—indeed, it flourishes especially in Christian countries—and even though churchmen take the lead in movements toward racial equalitarianism, their congregations are not practicing brotherhoods. A Negro Episcopalian and a White Episcopalian may kneel at the same altar in a New York church, although they are not likely to meet at the same dinner table; but Southern Negro Baptists and Southern White Baptists go by separate paths toward God.

Similar statements can be made about democracy. Democracy as a faith in the

common man and as an expression of the doctrine of personal liberty and equality, rather than of property rights, drew many of its early leaders from our Old South. Yet it was the South which modified that conception to exclude almost half its population as unfitted for democracy on racial grounds. Jefferson could believe in an equalitarian democracy because he believed that slavery was passing. When slavery and profits became one thing, the South produced Calhoun to justify slavery and to reduce democracy to something like what it had been two thousand years before in Athens.

The revolution in Russia, on the other hand, greatly reduced racial discrimination in that country. It is notable that equal treatment of races appears in societies where an old structure is broken, and among those members of any society who are least involved in an established social structure. It is the Bohemian, not the Philistine, who admits all races at par Professional players of popular music, who might be regarded both as artists and as a kind of migratory labor, show little color discrimination It is the newer and the more heterogeneous C I O, and not the established and more homogeneous A F of L, that extends a hand of welcome to the Negro. This is the reverse of a proposition about race that we have already made. Where race becomes attached to a social category, the category is made more rigid, more difficult to break through. Correspondingly, where social categories are broken down by revolution or overwhelmed by some more important category, as a religion of brotherhood, race may lose its social importance in whole or in part In a time of war both aspects of the process are present. In so far as we are insecure and fearful, we tend to fix upon an enemy, and there is some disposition to find that enemy in a racial group. There is an inclination to define the Japanese as enemies, racially. Anti-Semitism has certainly not been eliminated from our country during the course of the war, and the fact that the Germans found their scapegoat in the Jew is no insurance that we are not to make a similar choice On the other hand, the necessity which this war brings to make explicit our doctrine of democracy emphasizes with new clearness the places in which we do not practice that democracy. How matters will develop out of these inconsistent tendencies in our national life it is not possible safely to predict

SCIENCE AND CAUSATION

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ALTHOUGH reason, order, intelligibility, and their corollaries form the framework of science, it cannot be said that the doctrines of scientific men always accord with them. Since the introduction of statistical methods for analyzing great masses of data, and the consequent emphasis upon correlation rather than causation, and since the wide and rapid acceptance of "the principle of uncertainty" in physics, a disposition rather antithetical towards logical rigor in science has been noticeable An impressive recent instance is the presidential address of Dr. Irving Langmuir to the American Association for the Advancement of Science Dr. Langmuir addressed the association on the subject, "Science, Common Sense and Decency." One of the principal topics in his address was causation. He says of this: "The net result of the modern principles of physics has been to wipe out almost completely the dogma of causation "[1]

Is causation a dogma? It is not such, by any means, in logic or metaphysics In antiquity it was already under challenge from the Greek sceptics, so again from nominalists in medieval times, while Hume, in the eighteenth century, withdrew whatever might have been supposed to be positive grounds for it. The idea persisted in science, evidently, for Mach thought fit to propose the abandonment of it[2] If an idea which has been so often repudiated continues to recur, a scientific man will perhaps say it must have a cause Common sense is even more certain of this Kant, in the *Critique of Pure Reason,* investigates the question, with the well-known result: causality is an a priori category of understanding; not a law of nature, but a mode of relation, in the mind, by which the mind explains phenomena.

A powerful determination of the mind to apply the causal concept in the way Kant describes may be observed in scientific writings, even when the writer questions causation, as for example, Dr Langmuir does in his own essay. We find there frequent mention of prediction, probability, laws of chance, and definition. The author even goes so far as to say "we still have to deal with causes and effects"; we "must plan for the future"; and though we "do not believe that definite results will inevitably follow," yet we can proceed by "estimating probabilities "[3] Now, of course, prediction and probability rest on assumption, and the assumption may be fairly regarded as an instance of Kant's category at work If the term *hypothesis* is more agreeable, it will serve equally well; for it signifies that we are giving to the data before us a certain order and necessity; and this is the same as Kant's meaning. Such order and necessity certainly are not observed by the eye, which only reacts to sensory data. To be sure, we are not obliged to make assumptions or hypotheses, but if we do not make them, we are left to impressions entirely, and prediction does not occur nor does science

Causation is a concept having a long history and many interpretations. Some of the most ingenious thought has been devoted to this subject. But causation is a metaphysical subject; hence scien-

[1] *Science,* Vol. 97, No 2505, p. 3 January 1, 1943

[2] *Science of Mechanics,* English translation, pp 580 ff Open Court, 1942

[3] *Loc cit.,* p. 6

tific men, or American scientific men at least, shy away from it This is truly remarkable. Had the mathematician shrunk from thinking about number, class, relation, etc, or the composer renounced scales and harmony, merely because these are not tangibles, the consequence would be no less remarkable Is one to infer that the American scientist has an antipathy to reflection about the grounds and import of natural objects; that he does not concern himself about their intelligibility or explanation? Is he first and last an empiricist? I do not insinuate an affirmative answer. To the contrary, if one may judge by scientific writing and teaching, the empirical accounting of a body of data is hardly ever sufficient or final The scientist does go beyond that—and into metempirical snares. If he does not realize this, it is perhaps because he is so possessed by his projects or his laboratory, and so wedded to the metaphysical presuppositions he has always found convenient, that no occasion for circumspection arises. However, he is by no means unique in this regard. Casual reference to other pursuits than science will easily find him company

Dr Langmuir believes that "the principle of uncertainty" has given the quietus to causation so far as the phenomena of the atom are concerned This is because of the mutual exclusiveness of the experimental determinations of velocity and position in the case of moving atomic particles But in order to disprove causation either within or without the atom, it would be necessary to show that given events, such as the appearance of a certain particle in a certain position, or at a certain rate of motion, were independent of all possible antecedents and grounds This, however, is quite beyond our present or prospective reach; even the data and findings of Professors Heisenberg and Bohr, I believe, do not imply so momentous a consequence. (It may indeed be that the findings of these distinguished men merely illustrate, not annul, causation; for if I am not mistaken they show obscuration now of position, now of velocity—and this obscuration is itself the effect of a cause, such as radiation)

Discussion of the "uncertainty principle" in scientific writings (we may notice that it can hardly be a principle unless certain, that is, unless entailing the paradox of uncertainty certain) is beset by the temptation to allow a radical difference between what used to be called molar and molecular dynamics But at once this difference vanishes; for the molecular scale submits to statistical accounting, and so does the molar—even the astronomical Inequalities are said to "average out," and in Dr Langmuir's paper we read of "unmistakable experimental evidence that these phenomena of the behavior of single atoms depend upon the laws of probability and that they are just as unpredictable in detail as the next throw of a coin."[4] A student of philosophy would observe that anything depending upon the laws of probability is *eo ipso* determinate so far as those laws are indeed laws, hence that the admission of such laws within atomic phenomena is an admission of causal relationship In much writing about the uses of statistics and probability theory it appears that the concept of causation has been abandoned, if not denied, and has been replaced by correlation But logical analysis will show this to be a patent misapprehension To say, for example, that the probability of heads in the throw of a coin is 1 to 2, or the correlation of heads with tails in the long run is 1, is a far different thing from saying that there is no determination whatever as between the two possibilities Might it not have been 2 to 3 and .666? So long as it is not that, why is it not? The whole affair, as between

[4] *Ibid.*, p 3.

coin-throwing and the system of nature, would be utterly different from what it is if this were a world of absolute chance. We should then have no certainty of an equality between heads and tails. So long as we do have this equality, or presume to have, it can not be explained by a blank, by the denial, that is, of grounds for it. In other words, if there is probability, there is implied order, or rational ground. Causality is simply a mode, among others, in which this ground is evident.

A slight application of logical analysis may show the presence of causality where not suspected. Suppose any event, *E*. Was it uncaused? Then it arose from nothing If it arose from nothing, that was the equivalent of the rise of 1 from 0, by magical involution, let us say. At the moment of its occurrence it was at once entity and nonentity. This would be a case in which *E* was not *E;* that is, total self-contradiction. Now it may be that events do come about in this manner —that time is a continuous making, out of what to us before seemed nothing If such is the case, emergent evolution, vitalism, intuitionism, and possibly mysticism and make-believe have sustained their claims. And if the scientist wishes to know the whereabouts and standing of science under that régime he can find out by consulting the writings of the late ingenious Henri Bergson

If we can not brook self-contradiction and chaos, we shall have to reject the notion that *E* comes from nothing. But to reject that is to affirm that it came from something, which will have been what is meant, in part at least, by the term *cause*. In short: if the effect, then the cause. This obviously pertains to a congeries of small-scale events, like those in an atom, the same as it does to a sequence of large-scale events in common experience. The whole matter comes to this: either causation or unintelligibility.

Dr. Langmuir admits that causation is able to account for "convergent" events but thinks it lacks bearing on events which he calls divergent ("those in which a single discontinuous event . . . becomes magnified in its effect so that the behavior of the whole aggregate does depend upon something that started from a small beginning"). Examples of divergent events are such as the emission of an alpha particle, or the sudden freezing of water when agitated, though the water, when still, may have remained unfrozen, at a temperature well below freezing.[5] But this distinction between convergent and divergent seems unreal. Any convergent event whatever, for instance the expansion of a body on heating, could be plausibly explained as a divergent event since its antecedents have an indefinite extension; or, conversely, since it is the culmen of a series projected from some uniquely selected origin in the incalculably distant past.

The criterion of large effects from small beginnings, which seems to be the main mark of divergency here, is open to much objection. For instance, there might be no noteworthy effect whatever of the emission of alpha particles, whereas a small boy free with matches might initiate the burning of a whole city. The perceptible track left by an alpha particle in a suitable medium, the devastation left by the burning of a city, —both are cognizable as causal phenomena. We may note that Dr. Langmuir uses the term "effect" in the passage quoted. Is this effect an effect of nothing or is it an effect of something? If the first, it seems unintelligible; if the second, it admits cause, and surrenders the question.

Like many other scientific writers, Dr. Langmuir regards predictability as the test of causation. But the two are hardly so close as that. My inability to predict the advent of a nova or the turn of the market, or the inability of all men to do such, would not affect the causal principle by which these do occur; and

[5] *Ibid.*, pp. 3–4.

on the other hand, my assurance that Sunday will be followed by Monday, is by no means either an index of that event or the same thing as it. Predictability seems to be psychological rather than an ontological category. Retrospection is probably closer to causation than prediction.

According to Dr. Langmuir, logic, too, is undermined along with causation. This is partly because "the law of the uniformity of nature" (as he terms it), which he calls a fundamental postulate of logic, has been overthrown by the "principle of uncertainty." But the student of logic has no dependence on this "law." It is apparently an induction, put forth by Mill, not to justify or aid logic but rather natural science. Prediction, probability, natural law, all depend on it, but not logic. Dr. Langmuir also cites the law of excluded middle (between a term and its contradictory there is no middle ground), observing that it has been affected by the same influences as the uniformity "law." But the student of logic is well aware that the principle of excluded middle still holds in what he calls a two-valued system of reasoning, that is, a system in which a term does or does not have a given predicate, or a proposition is or is not true. Instead of being true or false, a proposition may be impossible or meaningless, and a logic which accommodates such additional categories is called many-valued. This expansion of logic does not invalidate the excluded-middle principle. How could it, except by applying that principle itself, hence acknowledging it? Moreover, the whole question respecting that principle is still *sub judice* But evidently it is no matter to Dr. Langmuir, who thinks neither the uniformity postulate nor excluded middle has much part in science now. It may be of interest to note, however, that mathematics takes a large part in the progress of science, and that after much fire at the foundations, mathematics still stands on the excluded-middle principle.

Having rejected so much, Dr. Langmuir has little left by which he can explain the phenomena of nature or the achievements of science. Common sense, good judgment, and intuition are the constituents of his epistemology. This is an impressive admission. If these terms are intended in the usual sense, one may feel assured that they omit the greatest part of the intellectual apparatus of modern science; while if they mean more than that, or let us say if they mean what is signified by terms like technology, methodology, and reason, then they reinstate the ideas which they were thought to replace.

Inconsistencies or difficulties such as we see here are easily understood. American education, especially scientific education, pays too little attention to reflection on principles. We are in the pioneering stage, concerned far more with objects and common sense than with systematic understanding. It results that we are often found in serious inconsistency and are indifferent to discoveries and speculations beyond our workaday acquaintance Dr. Langmuir mentions logic, as I have noted. In logic there exists a large body of recent work which is of the highest importance to those who think. Although this includes a treatise which for penetrataion and intellectual magnificence might be thought entitled to the homage of every mind, and has received it from the acutest minds during the generation since its publication—viz, Whitehead and Russell's *Principia Mathematica*—and although many other works of great brilliance and of late authorship are also found here, it can not be said that scientists, except mathematicians, have paid it much attention. At that, logic no doubt receives more scientific notice than metaphysics or epistemology. Scientific men often affect a dread of metaphysics; and to the major-

ity, no doubt, epistemology is an equal or even greater bogy. It is hard to see how any gain can come from this cavalier attitude. A person can not think without making himself something of an epistemologist, and he can not think about things without becoming a metaphysician. There is only one question in the matter: how far does he think? If he is satisfied to manipulate instruments and read tables, then certainly we have no philosopher (and it is doubtful that we have a scientist, though he may be an excellent mechanic or timekeeper). If, on the other hand, he does think things out, he comes to see that questions about causation, implication, order, fact, meaning, etc., are far from being matters of opinion and indifference. All of them are interconnected, and the domain of science lies full amidst them. The continued disregard of anything so patent, by the educators of scientists, is indefensible. Dr. Langmuir seems to deplore the morality that has issued in the present war. There is good reason for deploring its analogue in education, especially in scientific education, namely, the habit of disregarding the mind and fixing all on bodies and interactions of bodies. Understanding, which is the goal, presumably, of all our inquiries, is dependent in many connections on bodies. But not in all connections. The history of science, not to speak of other spheres, is a profound lesson in the hegemony of the mind. Non-scientific persons, observing this, are sometimes tempted to think that if, during scientific education, reflection, with its grounds, criteria, and ends, were more emphasized in its own right, the problems of science would be more rapidly solved (or dissolved) than they are.

SCIENCE AND THE CONCEPT OF FREEDOM: A TRIBUTE TO GALILEO[1]

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PERHAPS "science" is not a satisfactory word symbol. Like all general terms it has too many connotations. These depend on the background, intelligence and conditioning of the user of the word. Like all word symbols for which there is no specific referent, the idea symbol "science," like the idea symbols "freedom," "justice" or "the state," may have just as many different meanings as there are people to employ these symbols. It matters little if the general idea about the symbol is agreed upon; difference in emotional conditioning to the symbol may produce emotional reactions when the symbol is used, which may make impossible a meeting of minds.[2]

Science is generally misunderstood by the mass of humanity. Freedom as a concept is often confused with licentiousness. We should be careful how to use word and idea symbols, if we wish to have clear understanding of our meaning. Perhaps this is why most intellectual discussions begin with definitions of the terms to be used.

[1] From the symposium on "Natural Philosophy" commemorating the 300th anniversary of Newton's birth and Galileo's death, which was to have been presented at the New York meeting of the American Association for the Advancement of Science.

[2] C. K. Ogden and I. A. Richards, *The Meaning of Meaning*, 5th ed., New York and London, 1938.

Science and Freedom

To intellectual Westerners the term "science" means in general that body of organized knowledge about ourselves and our environment that has been subjected to verification by observation or experiment. By the concept "freedom" intelligent Westerners usually mean *responsible* conduct and discussion unhampered by arbitrary external force or fear of such force—responsible in the sense that it is logically and reasonably determined by the circumstances in the situation

Of course there is much more to "science" and to "freedom" than these general statements Science is as much an attitude of mind as a body of organized knowledge Freedom also is as much an attitude of mind as it is a state of being

To a great extent science is a method of thinking and a method of procedure for the acquisition of knowledge The aim, method and spirit of science have been frequently discussed [3] The aim of science seems to be to know the "truth" about ourselves and our environment. By the often abused idea symbol "truth" a scientist means an objectively demonstrable and intellectually coherent explanation of ourselves and the universe.

The method of science involves rigid self-criticism as one proceeds. This is necessary in order to achieve an objectively demonstrable explanation. One method is mathematical to build by experimental reasoning within the strict limitations of logical consistency, a coherent ideal system with which some of the details of the universe may be found, on experiment, to correspond. Another way is biological and empirical: by observing and describing as carefully as possible some phenomenon in our environment or in ourselves, and then going on to offer a tentative explanation of it, the validity of which may be tested by experiment, and then confirming or modifying our explanation in accordance with the results of such experiments

The spirit of science is the key to the problem. It involves the concept of "freedom" in such a way as to imply the impossibility of science without freedom The spirit of science implies freedom to seek the "truth " The spirit of science implies not only freedom to have and to express any view for which there is rational evidence, but also recognition that knowledge of ourselves and the universe is incomplete and subject to revision, and that there is, therefore, no justifiable compulsion to belief beyond *voluntary* acceptance of demonstrably rational evidence

The spirit of science implies *responsible* freedom in forming individual judgments, and in expressing them. It refuses to acknowledge the justification of any compulsion to belief that is arbitrary, or that involves in any way anything beyond the voluntary acceptance of what is demonstrable to the senses and reasonably or logically derived therefrom The spirit of science acknowledges no "authority," except voluntary and uncoerced agreement among reasonably competent scholars on the basis of the objective evidence available.[4]

Galileo and Freedom of Science

We are paying tribute to Galileo Galilei (1564–1642) chiefly because he appears as a leading protagonist in the struggle of science with arbitrary authority Developing the method of critically controlled observation and experiment, Galileo exemplified, as Castiglioni emphasizes, the free-thinking characteristics of his time This was the age of Shakespeare, Bacon, Milton, Gilbert and Harvey in England, of Kepler, Cervantes

[3] E. G. Conklin, *The Direction of Human Evolution*, New York, 1921; C. D. Leake, "Science Implies Freedom," in *Studies in the History of Culture*, Philadelphia, 1942.

[4] C. D Leake, "Religio Scientiae," *The Scientific Monthly*, 52: 166, 1941.

and Descartes. The world was opened to the survey of man. In the year of Galileo's death, Newton was born, destined to expand amazingly his intellectual heritage. The first fruits of science testified abundantly to the strength of the root-stock which had been started two millennia previously by the Greeks and which finally had been pruned of much thorny foliage during the Renaissance.

In his popular demonstrations Galileo showed that sensory perception, uncontrolled by careful reasoning, may lead one into as much error as reasoning uncontrolled by experiment. The threat of Galileo's ideas was quickly realized by that established and arbitrary authority which assumed the power to force men to believe, or at least to say that they believed, what that authority decided they should believe.

In 1616 Galileo was reprimanded by Pope Paul IV for the ideas he had expressed. He was told not to "hold, teach, or defend" the condemned doctrine of Copernicus, whose theory Galileo had tried to reconcile with the accepted traditional cosmology of the church.

In 1630 there was published in Florence the famous *Dialogo dei due Massimi Sistemi del Mondo Tolemaico e. Copernicano.* In 1632 this book was banned by Pope Urban VIII for heresy and breach of good faith. Galileo was examined by the Inquisition, was threatened with torture, and was sentenced to imprisonment. By way of penance he was compelled once a week for three years to recite the seven penitential psalms.

On Galileo's death in 1642, his anxious wife, hoping to preserve his good name and position, showed to her confessor what manuscripts remained. It is said that he destroyed them as heretical. Two years later John Milton (1608–1674) wrote his famous "Areopagitica: A Speech for the Liberty of Unlicenc'd Printing." Immediately this eloquent plea for freedom of the pen was condemned by Cromwell and the Parliament of Protestant England. In 1641 in Paris was published the *Meditations* of Rene Descartes (1596–1650). Descartes had modified his writings, on learning of the suppression of Galileo's ideas, and had abandoned a project in confirmation of Copernicus Subsequently the *Meditations* was placed on the *Index Librorum Prohibitorum,* where it still remains.

Three centuries later we may look back upon much of this as silly. The factors behind the seventeenth century difficulties, however, are still with us and are unreconciled in spite of the many protestations that there is no longer any conflict between religion and science. It is clear that the purposes of religion and science are the same, namely, to know the "truth." The difficulty remains in what constitutes the "truth"

Ethical Significance of Science

Science has a particular, specific and well-defined criterion for "truth" This varies significantly from what is considered to be the "truth" by the churches, which are the custodians of religious ideas, and now by certain governments, which claim supervision of the thought of their peoples. Psychologically conditioned acceptance of such supervision constitutes now the gravest threat to the requisite freedom of science. The freedom of science in seeking the "truth" in accordance with its criteria seems to be as essential a freedom as any of the now famous four. Perhaps it was encompassed by President Roosevelt and Prime Minister Churchill in all their four—freedom of expression, freedom in worship, freedom from want and freedom from fear—since these are so clearly implied in the spirit of science, which proposes that belief and conduct

depend on the logical consequences of our verifiable and always increasing knowledge of ourselves and our environment.

For science has significant ethical consequences. These were suspected by Plato, indicated by Galileo, and now are beginning to be appreciated by an increasing number of English and North American scientific leaders Edwin Grant Conklin has vigorously supported this concept;[5] George Sarton has devoted his patient life to its exposition,[6] C Judson Herrick has expounded it;[7] Samuel Holmes has coolly considered it.[8] The Unity of Science movement embraces it, and recently C H Waddington has led a brilliant discussion of it[9] The American Association for the Advancement of Science has even devoted symposia to it.

At one of these sessions there were deliberate consideration and tentative agreement with an objectively realized principle, similar as a natural phenomenon to the gravity principle of Galileo which affords a scientific basis for ethics. The probability of the survival of a relationship between individuals or groups of individuals increases with the extent to which the relationship is mutually satisfying or agreeable, and beneficial or advantageous. This is merely a corollary of the evolutionary principle, but it becomes highly significant in view of the common human desire for satisfaction and the common human ability through the use of the brain to achieve it. The difficulty seems to be that brains vary so greatly!

The recent State Department "White Book," *Peace and War: United States Foreign Policy, 1931–1941,* illustrates international factors involving the operation of this principle. Thoughtful persons may derive pertinent examples from their own personal experiences and from the whole course of human history.

Galileo was persecuted in his attempt to explore, in the freedom of scientific inquiry, the implications of new appreciations of mathematical and physical principles Not for a long time to come is it to be expected that one may freely and openly investigate in the scientific way the implications of newly realized biological principles, to which we as living organisms must conform. The equanimity of Galileo may serve us well for many centuries as an example, in the predicament which scientists may expect unless freedom of science is included in our world charter. Perhaps we may someday learn that individuals may achieve more as individuals by cooperation than by competition

[5] E. G Conklin, *The Scientific Monthly,* 49: 99, 1939

[6] George Sarton, *An Introduction to the History of Science,* Vol 1, Baltimore, 1927, *The History of Science and the New Humanism,* Harvard, 1937.

[7] C. J. Herrick, *The Scientific Monthly,* 49: 295, 1939.

[8] S J Holmes, *Science,* 90: 117, 1940.

[9] C H. Waddington, *Science and Ethics,* London, 1942

NATURE'S BRIDGES

By Dr. RAYMOND E. JANSSEN
DEPARTMENT OF GEOLOGY, MARSHALL COLLEGE

ALLURING, entrancing, mystifying—the sight of a beautifully executed bridge unfailingly captures the imagination of the observer. Whether fashioned of stone by Nature or designed of architectural steel by man, a sturdy bridge seldom fails to arrest one's attention This may be true, perhaps, because our fancies are at once quickened to an appreciation of the labors which brought the bridge into being. Then, too, a bridge always leads somewhere—often to new horizons and new experiences.

No one can question the importance of bridges in our daily lives. Even our ordinary conversations are colored with frequent references to bridges We say that if we stay on the bridge, we shall cross the river. How often are we reminded that we should not cross our bridges before we reach them? Or again, we are cautioned not to burn our bridges behind us. When we have triumphed in the face of tremendous odds, we say that we have bridged our difficulties. Bridges thus have come to represent stages in human experience.

Natural bridges, not designed and fashioned by the hands of man, are particularly interesting. They, too, represent stages, not in human experience, but in the orderly progression of an ever-changing world. Our curiosity is at once aroused by the sight of a natural bridge, and we can not refrain from speculating about the mighty forces which brought it into existence

What is a natural bridge? A geologist would say that such a bridge is a natural stone connection spanning a valley of erosion. Then he might add that a natural arch is similar, but does not span an erosional valley. The distinction is largely technical and not entirely clear to most of us Perhaps it would be more understandable to say that a natural bridge is one which spans a barrier, providing a natural means of crossing from one side to the other A natural arch, on the other hand, might be called an opening through a natural barrier, just as an arched doorway affords a passage from one room to another In other words, we cross upon a bridge, but pass through an archway. The matter of definition is, after all, of little importance Of interest, primarily, is the manner of origin of these natural features.

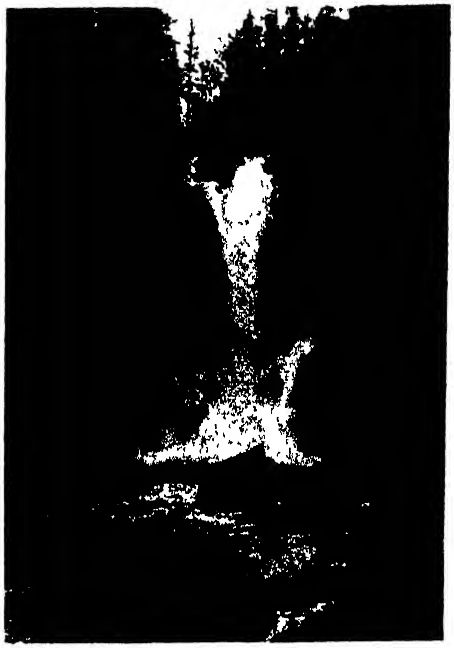
Best known of all natural spans in America is the Great Natural Bridge of Virginia. It is more than two hundred feet above the stream which passes under it. This natural bridge is of sufficient size and strength to accommodate an automobile highway. United States Highway Number 11, extending from New York State to New Orleans, crosses upon the natural bridge. The origin of this bridge, composed of limestone, is attributed to the collapse of the roof of an underground cavern At some time in its history, the stream which passes below flowed through an underground passage at this point. Eventually a long subterranean cavern was developed along the course of the underground stream. The greater portion of the roof of this cavern subsequently collapsed, leaving only a small portion still spanning the former cavern. This remaining span thus became a natural bridge, and the underground stream became a surface stream. Smaller, less celebrated natural bridges, formed in similar ways, are found in other parts of America

where soluble limestone constitutes the bedrock

Natural bridges may also mark the sites of former waterfalls. Sometimes water which is headed for a plunge over a precipice finds an outlet through cracks in the rock strata behind and below the brink. Such trickles of water make a detour around the waterfall proper and emerge beneath it In the course of long periods of time this passageway may become enlarged to the extent of diverting all the water. When this happens, the brink of the waterfall becomes a natural bridge with the water flowing beneath it. Such a bridge may be seen along the course of the Kicking Horse River in Yoho National Park, British Columbia

To appreciate best the manner in which such bridges originate, one should view Trick Falls (also called Double Falls) in Glacier National Park. Trick

THE GREAT NATURAL BRIDGE OF VIRGINIA, 200 FEET HIGH, WAS FORMED BY THE COLLAPSE OF A CAVERN ROOF. A NATIONAL AUTOMOBILE HIGHWAY CROSSES UPON THE SPAN.



TRICK FALLS, OR DOUBLE FALLS IN GLACIER NATIONAL PARK, REPRESENTS AN INTERMEDIATE STAGE IN THE FORMATION OF A NATURAL BRIDGE MUCH OF THE WATER BYPASSES THE UPPER PORTION OF THE FALLS AND EMERGES FROM THE GROWING OPENING BENEATH.

Falls today represents an intermediate stage in the formation of a natural bridge In the spring and early summer, when the flow is great, vast quantities of water plunge over the brink in normal fashion. At the same time, one may also see water emerging from openings beneath the falls. But in seasons when the flow is greatly diminished, no water plunges over the falls; all of it is diverted through the lower opening. As this geological process is continued in the future, the opening will be enlarged to the extent of accommodating all the water during all seasons. Trick Falls will then become a true natural bridge.

Largest and most impressive of all natural bridges are those which have been formed by ordinary stream erosion. The finest known examples of these are located in the remote canyon regions of our arid Southwest. The sandstone in

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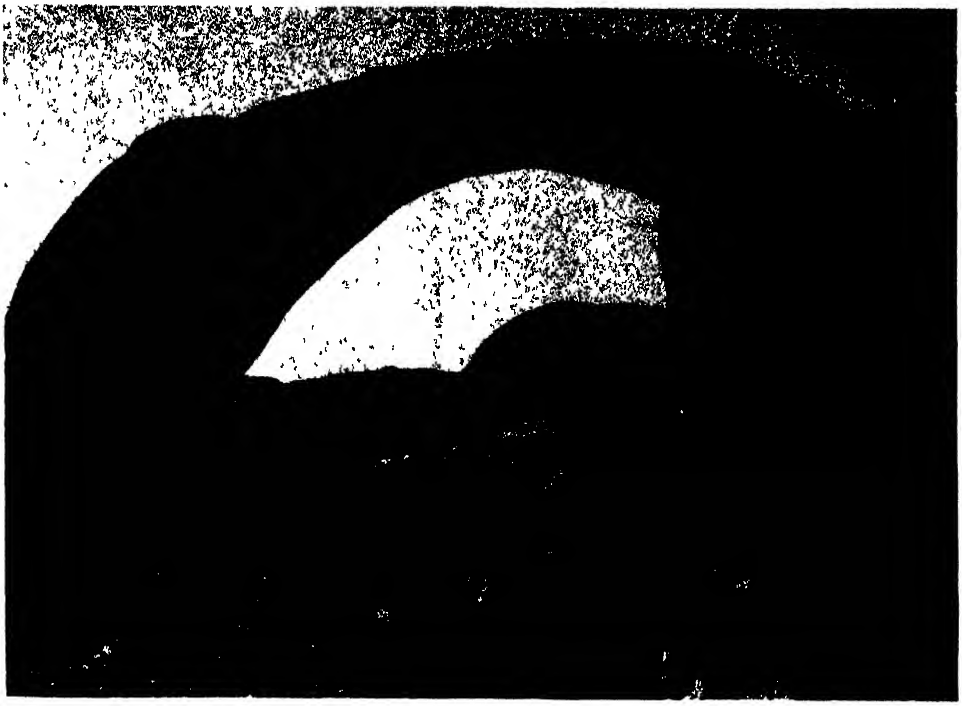
SIPAPU, OR AUGUSTA, BRIDGE

ONE OF THREE NATURAL SPANS CONSTITUTING THE NATURAL BRIDGES NATIONAL MONUMENT SITUATED NEAR THE HEAD OF WHITE CANYON IN SAN JUAN COUNTY IN UTAH IT IS 222 FEET HIGH AND 261 FEET LONG. THE SPAN IS 128 FEET WIDE AND 65 FEET THICK AT THE NARROWEST PART.

which these bridges are cut was originally laid down as unconsolidated sand near sea level and later compacted into massive rock under the weight of subsequent overlying deposits. Eventually the region was elevated far above sea level, becoming a vast plateau Streams, starting as a consequence of the uplift, began carving valleys across the newly formed plateau as the land was rising In newly uplifted regions, the valleys are narrow and deep because the energy of the stream is devoted primarily to down-cutting processes. If the uplifting of the land is intermittent or relatively slow, streams are able to widen their valleys as well as deepen them In the widening processes, the streams develop meandering courses characterized by great curves and loops. If the land is further uplifted after the streams have developed such meandering courses, they must again concentrate on the deepening processes, thereby entrenching their winding channels below the level of the original valley As a result, deep, circuitous gorges may exist within the depths of old valleys

In many places the streams have formed great loops which are almost complete circles. Within such loops are long spurs, or peninsulas, of rock which have narrow necks Since winding streams cut mostly along their outside curves, there is a continuous tendency to narrow the necks from each side by impingement of the turbulent current In time the stream waters undermine the rock walls, eventually breaking through the narrow necks and taking a short cut through the hole thus formed The rock remaining above the opening thereby becomes a natural bridge spanning the new course of the stream. Subsequent erosion and low-



Santa Fe Railroad

RAINBOW BRIDGE IN SOUTHERN UTAH, 309 FEET HIGH

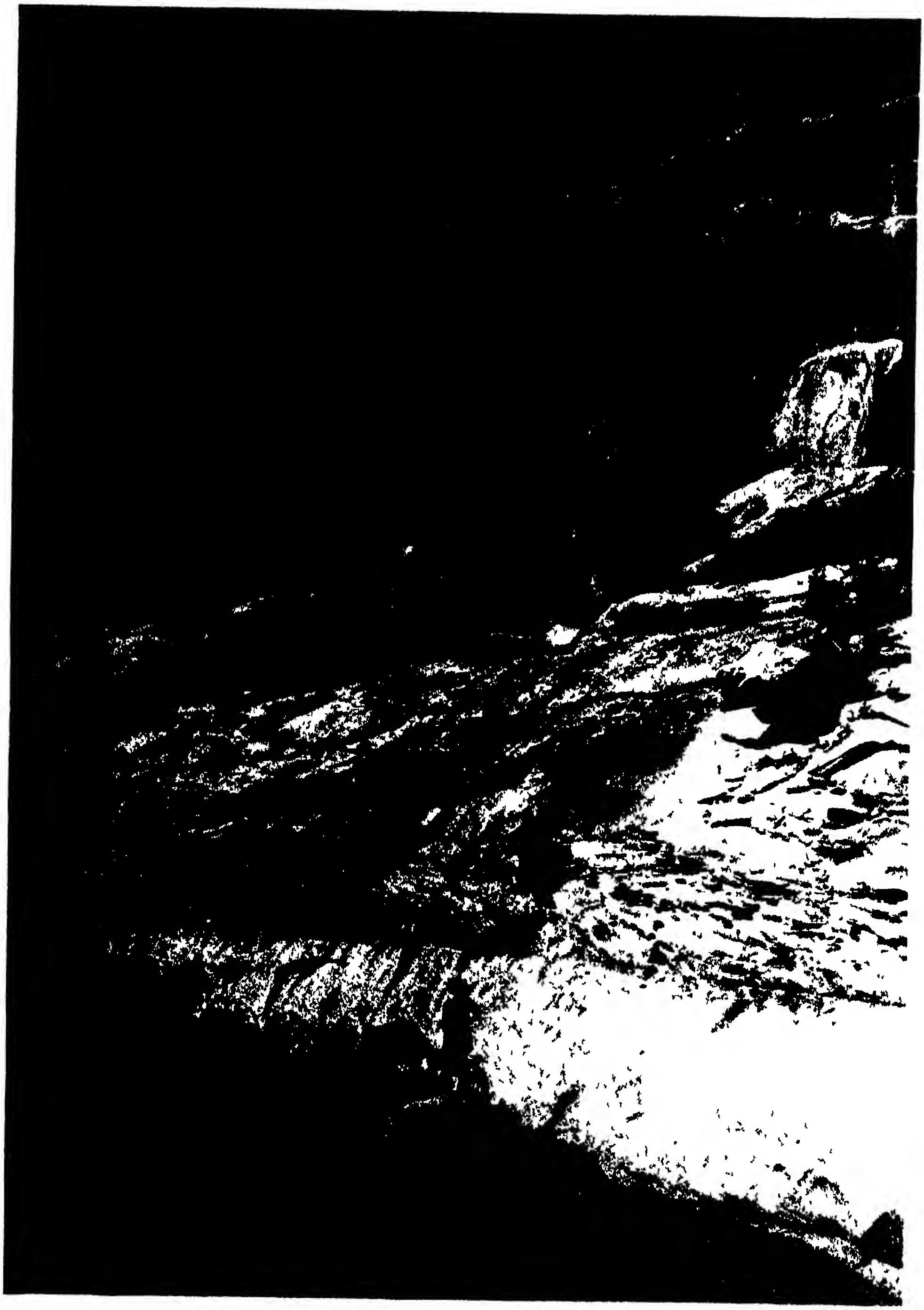
WORLD'S LARGEST KNOWN NATURAL BRIDGE. ITS ARCH WAS FORMED BY A MEANDERING STREAM WHOSE WATERS DASHED AGAINST A MASSIVE SANDSTONE SPUR, EVENTUALLY UNDERCUTTING IT.

ering of the new channels, in some cases, have formed small gorges beneath such bridges

Foremost among natural bridges formed by ordinary stream erosion is Rainbow Bridge, the largest known natural bridge in the world It is located within the Piute Indian Reservation in southern Utah, just north of the Arizona boundary. Composed of pinkish sandstone, it presents a symmetrical arch with a curved upper surface, roughly similar to the arch of a rainbow In the Piute language, the bridge is known as "Barahoini," or rainbow. The Navajos refer to it as "Nonnezoshi," meaning arch, or hole-in-the-rock Sometimes they call it "Nageelid Nonnezoshi," the rainbow arch.

Rainbow Bridge spans a portion of Bridge Canyon, which extends between the Colorado River and Navajo Mountain The span measures two hundred and seventy-eight feet from pier to pier, and towers three hundred and nine feet above the stream bed in the gorge below; hence a building having the proportions of our national Capitol at Washington could be erected beneath the bridge with ample room to spare. At its thinnest point the bridge is thirty-three feet wide and forty-two feet thick.

So far as is known, Rainbow Bridge was first seen by white men on August 14, 1909, when a party headed by Professor Byron Cummings, then of the University of Utah, visited the region. He had learned of the existence of the bridge through vague information furnished by a Piute Indian who had seen the bridge and agreed to guide a party to it. The following year, on May 30, 1910, President Taft proclaimed the bridge a national monument. Situated



U S Dept of Interior

OWANCHOMO, OR EDWIN, BRIDGE OF THE NATIONAL MONUMENT GROUP, UTAH

MOST TRULY BRIDGE-LIKE IN DESIGN OF ALL OUR NATURAL SPANS. IT IS 194 FEET LONG AND 108 FEET ABOVE THE STREAM BED ALTHOUGH ONLY 10 FEET THICK, THE BRIDGE IS 35 FEET WIDE.

in one of the most inaccessible canyon regions of our country, Rainbow Bridge can be reached even now only by pack train, requiring at least three days for the round trip from Navajo Mountain, the terminus of the present automobile highway.

Farther north in this great plateau country is located a group of three natural sandstone bridges of great size and beauty, all within five miles of one another. Situated near the head of White Canyon, in San Juan County, Utah, they comprise the Natural Bridges National Monument, established by President Theodore Roosevelt on April 16, 1908

It is not definitely known when these bridges were first seen by white men, although their presence was reported as early as 1883 by a prospector named Cass Hite. They did not become generally known until after March, 1903, when Horace J Long, a mining engineer, was guided to them by James Scorup, a cattleman. Scorup had caught distant glimpses of them in 1895 while herding cattle on the range Accounts of Long's visit, carried in the *Century Magazine* of August, 1904, and in *The National Geographic Magazine* of September, 1904, led ultimately to the establishment of the national monument.

Most massive of these three bridges is Kachina Bridge, also known as Carolyn Bridge. The latter name was given it by Long after the name of the mother of James Scorup. Under presidential proclamation, the Indian name was applied because of a symbol carved on one of the buttresses and recognized as that of the Kachina, guardian spirit and symbol of the sacred dancers of the Hopi Indians. This bridge has a span of one hundred and eighty-six feet, and a height of two hundred and five feet above the stream bed At the top it has a width of forty-

U. S Dept. of Interior

KACHINA, OR CAROLINE, BRIDGE IN UTAH

ITS INDIAN NAME IS TAKEN FROM THE ANCIENT HOPI SYMBOLS CARVED UPON ITS SIDES. THE SPAN IS MASSIVE, HAVING A THICKNESS OF 107 FEET AND A WIDTH OF 49 FEET AT THE NARROWEST PART.

U S Dept of Interior

THE GREAT ARCH OF ZION, IN ZION NATIONAL PARK, UTAH

EXAMPLE OF AN UNCOMPLETED NATURAL BRIDGE FORMED BY THE EROSIVE ACTION OF A STREAM. THE GREAT SPAN, ONLY PARTLY CUT THROUGH THE ROCK, IS 722 FEET LONG AND 585 FEET HIGH.

nine feet, and a thickness of one hundred and seven feet at its thinnest point.

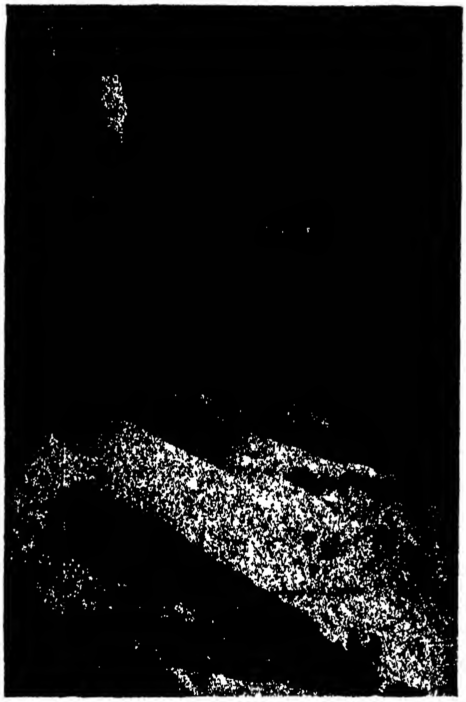
Larger, however, is the Sipapu Bridge, originally called Augusta Bridge in honor of Long's wife. In the Hopi language Sipapu means "portal of life" and refers to a mythical hole, or opening, between the lower and upper worlds through which the Indians believe they enter this life After death they presumably return again to the lower world through the Sipapu, remaining there for a time before ascending to the heavens to become raingods. The bridge has a span of two hundred and sixty-one feet and towers two hundred and twenty-two feet above the stream bed. The great span is one hundred and twenty-eight feet wide and is sixty-five feet thick at its narrowest point, hence it could easily accommodate a modern superhighway.

Smallest of the three bridges, although massive itself in size, is Owanchomo, or Edwin, Bridge. Originally called Little Bridge by Long, it was renamed Edwin Bridge by an expedition sent out in 1905 by the Salt Lake Commercial Club, and ultimately it was rechristened Owanchomo by President Roosevelt This name, meaning "flat-rock mound," was derived from the Hopi name of a nearby rock formation The bridge has a span of one hundred and ninety-four feet, and rises one hundred and eight feet above the stream Viewed from a distance, it seems incapable of supporting its own weight, since it is only ten feet thick near the central portion Its width, however, is thirty-five feet, and comparable to that of an ordinary highway. When visited by Long, his party was the first to ride across it on horseback. Owanchomo Bridge is situated in an unnamed canyon near its confluence with Armstrong Canyon, which is, in turn, a tributary of White Canyon

U S Geological Survey

A NATURAL ARCH ALONG THE SEACOAST OF THE GASPÉ PENINSULA

FORMED BY THE POUNDING OF THE WAVES UPON A THIN WALL OF ROCK JUTTING OUT INTO THE SEA.



Chicago & North Western Railroad

NATURAL ARCHED WINDOWS FORMED BY RAIN AND WIND

IN THE WALLS OF BRYCE CANYON NATIONAL PARK, CENTRAL EASTERN UTAH. THE CAPROCK IS HARDER THAN THE STRATA BELOW, PERMITTING THE FORMATION OF THESE UNIQUE STRUCTURES.

The three bridges are located about fifty-five miles west of Blanding, Utah An automobile highway extends from Blanding to within a quarter of a mile of Owanchomo Bridge To reach Sipapu and Kachina Bridges a long hike or horseback ride is necessary.

An intermediate stage in the formation of such a stream-formed bridge is portrayed by the Great Arch of Zion in Zion National Park, also in Utah. Here a stream in its downcutting process and lateral impingement has partially undercut a massive rock wall, forming an enormous arch. The span is seven hundred and twenty-two feet long and five hundred and eighty-five feet high. If the process were completed, the resulting bridge would be truly colossal and vastly exceeding in size even the remarkable proportions of Rainbow Bridge.

Although Utah has become noted for its natural spans cut by running water, it also has some which were not water-carved but were produced by the blasting action of strong desert winds Wind-made arches exist in Arches National Monument, located in Grand County, in the central eastern part of the state. The monument contains two tracts, separated by a wide desert valley. One section, called the "Devil's Garden," contains balanced rocks, spires and queer sandstone formations of grotesque shapes; and the other, known as the "Windows," consists of immense sandstone walls punctured by numerous archways and windows, resembling the ruins of some great fortification.

These openings range from small windows a foot or two in diameter to great natural archways more than a hundred feet in diameter. Eight of these are of enormous size, one being two hundred feet high and nearly circular in shape In this region strong prevailing winds pick up loose grains of sand from the desert floor, carry them for a distance, and hurl them with tremendous force against the sandstone walls, effecting a natural sandblast. During long ages the walls have been worn through at intervals, forming the many natural windows and arches This national monument, located near Moab, Utah, was established by President Hoover on April 12, 1929.

Occasionally natural bridges and arches are formed in more unique ways. Sometimes a large boulder may become lodged after falling into the top of a crevice, thereby forming a small, but nevertheless actual, natural bridge across a gap Waves beating upon shore cliffs may form large hollows or caves in the rocks; and portions of the roofs of such indentures may cave in, resulting in another type of natural span. Sometimes a large slice, or section, of a cliff may slump away at the base, leaving its upper

U S Geological Survey

PETRIFIED TREE LOG, UNDERCUT BY THE EROSION OF A STREAM

PRODUCES THIS UNIQUE NATURAL BRIDGE IN PETRIFIED FOREST NATIONAL MONUMENT, ARIZONA.

portion leaning against the cliff proper and forming a natural arch.

Probably the most unique natural bridge in America is the Log Bridge in Petrified Forest National Monument, Arizona This bridge consists of a huge petrified tree trunk spanning a gully The trunk is one of thousands of similar specimens which lie scattered in great profusion upon the surface of the ground The trees themselves were conifers, belonging to the group *Araucaria,* somewhat resembling modern pines, which flourished during the Triassic Period some one hundred and eighty million years ago. During their long burial in the ground the woody cells became replaced with mineral matter carried in solution by underground water. Subsequent erosion has removed much of the ground material which enclosed the petrified logs, leaving them scattered promiscuously about the landscape. A small stream, working across the region, gradually undermined one of the prostrate, petrified logs As the gully grew beneath and beyond the site of the log, the soft ground was carried away from beneath it, leaving the petrified trunk as a natural bridge.

Like most scenic formations, natural bridges are ephemeral features in an ever-changing landscape. The same agencies which fashioned them—the waters and the winds—are relentlessly wearing away the rock grains of which they are built. Many which existed in the past, have disappeared forever. Those which exist today will sometime disappear But others, still in the making, will loom in their stead Nature, the great builder and leveler of all material things, working hand in hand with time, is continually busy, designing and redesigning new structures in an ancient world

PEYOTE AND THE INDIAN

By D'ARCY MCNICKLE

ADMINISTRATIVE OFFICER, OFFICE OF INDIAN AFFAIRS, U. S DEPARTMENT OF THE INTERIOR

THE search for revelation, for everlasting, fulfilling truth, has occupied men of all races, at all times. At least we must assume this, from the wealth and variety of remembered or recorded experience And for all that it is so common a pursuit among men, it is surprising how intolerant men are of each other's vision. My prophets are but drivel-talkers to another, and another's messiah is my anathema.

The people we know as Indians were as assiduous in their search for the "truth" of things, as fertile in their imagining of creation and the world beyond life, and as sensitive to an affronting of their gods and their beliefs as any race that ever lived. Nevertheless, we frequently find people in the position of maintaining that while Indian beliefs are picturesque, interesting as specimens of benighted thought, they should not be treated very seriously They should not be allowed to stand too much in the way of a true vision of life

A case in point is the frequently discussed but little understood peyote cult existing in certain Indian tribes: a cult organized formally as the Native American Church in several states. In this instance, even fair-minded people who, if put to it, will concede that Indians, like all minority groups under our Constitution, are entitled to worship in their accustomed ways, draw the line at peyote worship, because—and this is odd—peyote is not native in the area north of Mexico. It is an imported religion! They do not deny that it is the product of Indian spirituality, which it is, and even recognize that it has transmuted certain Christian elements and certain Europeanizations. No matter It was not here when the Constitution was being written; therefore it is not privileged.

As if this were not a serious enough count against peyote worship, the substance peyote has long been the object of unsavory gossip, even, at times, of quasi-scientific denunciation. It is commonly referred to as a drug, which, in a strictly technical sense, it probably is; but it is also bracketed with the term "narcotic," which many believe is usually enough to condemn it forthwith Efforts have been made, unsuccessfully, to bar it from interstate shipment, and some states have prohibited its sale, use, possession or transportation

What, then, is peyote? Where did it come from? And when? Why have Indians created a worship around it? Literally, it is several things· a formalized religion, as already indicated; a healing ceremony, a reweaving of the social fabric of Indian life; a sharpening of perceptive powers in the individual. When taken internally, the substance frequently induces visions and feelings of power and well-being, a kind of soft intoxication without the after effects of alcoholism.

The peyote is a cactus, *Lophophorus williamsii* botanically, sometimes confused with other plants and given various names The ancient Mexican Indians used several narcotic growing things, one of them a poisonous mushroom, the identity of which was not at first distinguished so that even scientific literature was confused. At popular levels the confusion is even greater. In the United States, for instance, peyote

is often called the mescal bean, although it is neither bean nor mescal Mescal is brandy made from fermented juice or pulp of the agave, or mescal, plant, not a cactus at all. The bean misnomer comes from the fact that the poisonous red seed of *Sophora secundiflora,* a true member of the bean family, has long been part of ritual paraphernalia among Indian tribes of the Southern Plains

The most serious confusions of all, however, have been those made by careless, if well-meaning propagandists who often link peyote with marihuana, the dangerous habit-forming drug, with which it is not related either botanically or in physiological effect Recent press articles on the peyote cult, for example, were illustrated with crime photographs of marihuana addicts taken from police files Marihuana may be used by some Indians, as it is by other groups in the United States, but this use is not related to the peyote cult.

Most outsiders, including even those who have lived in Indian areas and believe themselves experts, have merely a superficial knowledge of the peyote cult, for while the exterior is easily seen, the inside meaning is hard to discover Anthropologists who have investigated the cult in many tribes know that beyond the peyote-eating feature there are peculiar sociological and psychological implications

While the peyote ceremonial reached the United States only about 1870, it was old in Mexico when the Spaniards arrived in the 1500's There, however, it was only a small part of the whole Indian religious and curing system, not a complete religion in itself as it became in the new environment of the United States In Mexico, peyote remains important today only among the Cora and Huichol Indians of the northern state of Chihuahua.

The ceremonial practice was brought into the United States by Apache tribes who inhabited the Rio Grande region of both countries, where the peyote cactus grows The plant resembles a small thick carrot, its head barely protruding above the ground This top, which contains euphoria-producing properties (as distinguished from narcotism), is cut ordinarily in October, and when dried it shrivels to the size of an overcoat button It grows more plentifully on the Mexican side, where it is harvested and sold to United States Indians.

The Mescalero Apache of southeastern New Mexico received the ceremony at about the same time as the Texas Apaches (around 1870) and gave it to the Kiowa and Comanche tribes on the neighboring plains of Oklahoma. These two groups became the main dispersion points to other Indians of the United States By 1890, the Wichita, Pawnee, Shawnee, Caddo, Delaware, southern Cheyenne and southern Arapaho were converts At the turn of the century the cult existed among the Ponca, Osage, northern Cheyenne and Winnebago. By 1910 it had completed its conquest of the Great Plains and had crossed the Rocky Mountains into the Great Basin area, where Ute and Shoshone groups took it up In the 1930's the cult crossed into Canada, where it now exists among the Cree, Blood and Canadian Chippewa, and a few years ago it appeared for the first time in northern California.

In some tribes the converts were a majority of the people, but in others the cult remained a minority practice. Its growth in each place depended greatly on the social soil it found and also on the personalities of the leaders or Indian messiahs who introduced it. The form of the cult varied too as it moved in time and space, so that it was not quite the same among the early Apache in New Mexico as it was among the recent Shoshone in Idaho or Nevada.

The appeal of peyote to the Indian mind and spirit is not too difficult to

MEMBERS OF THE PEYOTES ON THE FORT HALL INDIAN RESERVATION, IDAHO
BEHIND THEIR TEPEE AND TO THE RIGHT CAN BE SEEN CABINS AND A FEW OLD CARS.

discern. The quest for religious truth among Indians, as among other men, is a quest for power—not mundane power over other men, but the spiritual power of propitiation and supplication. A people that can not make itself heard by the supernaturals, or that has lost the power after once having had it, is a lost people. And Indians have been in exactly this situation. As they lost ground before the advancing white man, they sought frantically for the strength that would snatch them from destruction. Indian history is full of the stories of desperate messiahs who sought to lead their people into a new day. The greatest movement of this nature was the Ghost Dance religion, which started among the Paiutes in the 1870's and quickly spread to many Indian regions, wherever the fabric of the old Indian life was torn against the new white world and wherever Indian life was miserable and hopelessly disintegrated. When the United States Army suppressed the movement among the Sioux in the bitter winter of 1890, the last rebel effort of Indian life faded. A state of social frustration followed. On this fertile soil the peyote cult then grew, and some of the first peyote chiefs were former Ghost Dance leaders. The peyote movement offered peaceful conciliation and escape, rather than militant action; hence it did not arouse immediately the fear and hostility which the Ghost Dance encountered. By calling upon those very elements of Christian meekness and righteous living, which the white man had preached to the Indians, it won consideration which otherwise it would not have had. But it did not avert suspicion, and as it gained converts suspicion ripened into hostility.

It is to be expected that any substance exerting spiritual influence over the Indian mind would also find favor

as a curing agent. In Indian belief disease is commonly regarded as an evidence of displeased supernaturals. Curing the body is a matter of exercising evil and regaining the good will of the gods. The role of peyote is, indeed, of this very dual nature: the ceremony is performed as a communion of worship in which all partake, but as often as not it is a dedicated service directed at an ailing member of the group. A peyote leader could say quite earnestly—"This room [where the ceremony was held] is not only our church, it is also our hospital."

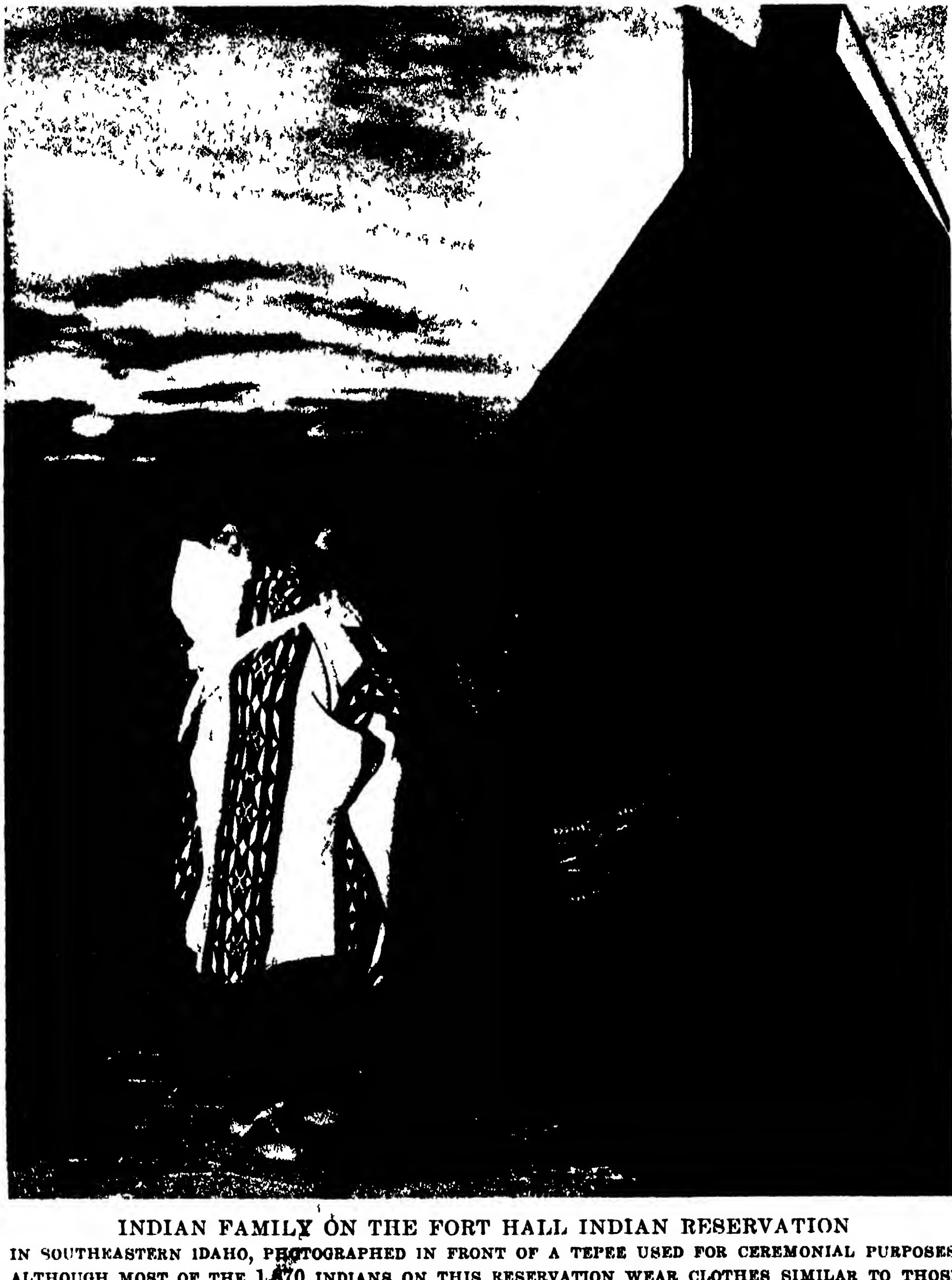
The actual ceremony varies in minor detail from tribe to tribe and from region to region, but the basic pattern is fairly constant.

Among the Cora and Huichol in Mexico the ritual is practiced at only one time of the year, but among the tribes in the United States it forms a year-round devotion. Frequently the meetings are held on Saturday night, continuing over into Sunday, following the pattern of Christian worship. Special peyote meetings are also sponsored by anyone wishing to celebrate a birthday or other special occasion, to cure illness, or to give thanks for recovery from illness They are also held in some tribes on national holidays such as the Fourth of July.

The meeting is usually held in a house or tepee. Many an Indian who builds a new home places the door at the east, so that during the peyote meetings he may see the rising sun of Sunday morning through the entrance In the center of the room a sickle or moon-shaped altar is built of earth or other material, its open arms, or horns, facing the eastern door In front of it a ritual fire is kept burning. Peyote buttons are placed on the middle of the moon altar, one of these being the fetish peyote, the "father" peyote, the incarnation of spirit force. This button is treated with respect, being handed down from meeting to meeting, sometimes for many years. The peyote that is to be eaten by the worshippers is kept in a sack.

Among many tribes women were at first not admitted to peyote meetings, but this restriction gradually wore down, for they too needed curing, like the men. Today the women usually make an outside circle behind the men, who sit around the walls on the floor covered with hay or sagebrush branches The most important person in the room is the peyote leader, or roadchief, whose name indicates that he is to lead his congregation along the road to spiritual abundance A line often traced from tip to tip on the moon-shaped altar represents this road of life. The peyote leader stands behind the altar, facing the door. The second important official in the meeting is the fireman, who keeps a slow fire burning and also acts as doorman The outside night is dangerous, and anyone who has to go out during the meeting must be magically protected against evil spirits, and cleansed when he returns, by the fireman. Both roadchief and fireman as well as their assistants use much ritual paraphernalia, including drums, feather fans, staves, whistles and other articles

The meeting starts after dark, and the worshippers attend in a mood of seriousness. They try to fix their gaze on the fetish peyote on the altar and on the flickering fire, and keep away all outside thought. The roadchief prays to the Father Peyote, who is the manifest God, just as Christ is the Father incarnate The leader eats the first four peyotes and passes the sack around until everyone has also eaten four. More can be eaten later in the course of the night, according to individual desires and tolerances for the cactus. The sick or old may be given peyote tea. The leader next sings four songs, accompanied by drumming by his assistant. These songs



INDIAN FAMILY ON THE FORT HALL INDIAN RESERVATION

IN SOUTHEASTERN IDAHO, PHOTOGRAPHED IN FRONT OF A TEPEE USED FOR CEREMONIAL PURPOSES. ALTHOUGH MOST OF THE 1,870 INDIANS ON THIS RESERVATION WEAR CLOTHES SIMILAR TO THOSE WORN BY WHITE PEOPLE, THEY ADD A BLANKET OR SHAWL OVER THEIR SHOULDERS AS A TRIBAL CUSTOM. MOST OF THESE INDIANS LIVE IN FRAME OR LOG HOUSES, BUT THEY STILL RETAIN MANY OLD TRIBAL CUSTOMS, AMONG WHICH IS OBSERVANCE OF THEIR PEYOTE RELIGIOUS CEREMONIAL IN AN OLD FASHIONED TEPEE, SUCH AS THE ONE SHOWN HERE THE WOMEN CARRY THEIR BABIES STRAPPED OVER THEIR SHOULDERS WITH A BLANKET OR IN A CRADLE BOARD.

THE FEAST OUTSIDE THE TEPEE AFTER A PEYOTE CEREMONIAL
THE FOOD IS PREPARED BY THE WOMEN AND OFTEN INCLUDES SUCH INDIAN DISHES AS BUFFALO MEAT. HERE INDIANS OF THE FORT HALL INDIAN RESERVATION IN IDAHO ARE BEGINNING THEIR FEAST ON LACE INLAY TABLECLOTH

may be very primitive, or well-known Christian hymns adapted to the occasion, or entirely new ones improvised by the singer. Each worshipper in his turn, with the exception of the women, also sings four songs At intervals in the singing, as the peyote affects the eaters, old men pray aloud or preach in great sincerity, tears often streaming from their eyes They may unburden themselves of their own problems or sins, or deal with the difficulties of others, or the illnesses of those present. There is a midnight break in the ceremony, when blasts from a whistle are blown, four of them outside the house or tepee, to let all living things in all directions know that the people are gathered there and need their help and power. Water is passed around and drunk, and the singing, praying and preaching are resumed, filling the rest of the night. At dawn the whistle blows again, a woman brings fresh water, and a ritual breakfast follows. Sweet foods are included in this meal, although their symbolical meaning is forgotten. After breakfast the meeting is officially over, and people for the first time walk around and talk to one another, telling what experiences or visions they had under the influence of peyote, or they lie around and sleep At noon a second meal is served, and after this everyone goes home

One appeal of peyote to the individual would naturally be the sensory stimulation produced, the feeling of ease, well-being and detached superiority Another appeal is its prestige value, for the peyote user is a person more important than the nonuser, in the eyes of his companions In olden times, and especially in the Plains area, centuries before the peyote cult, visions used to be sought often through drastic means and trials of endurance and the person attaining a vision became an important individual Some association with the former vision-quest doubtless exists in peyote, explaining further the appeal it has for the Indian mind.

Research into the physical properties of peyote, or of its physiological effects on the human organism, has not been ex-

haustive. It is by very reason of this incomplete knowledge that the attack on peyote has been so successful at times. Charges are made against it that are difficult to disprove, the facts being inconclusive Probably, also, it is not unfair to say that those who attack the cult make maximum use of what little evidence is available; while the friends who would protect the cult, and they have never been numerous, have found the scarcity of evidence a handicap. We summarize the material briefly

A number of alkaloids, including mescaline, anhalonine, anhalonidine, lophophorine and others, have been isolated from peyote, but none has ever attained commercial or pharmaceutical importance. Physiological and psychological experiments have been made with different ones of these compounds and also with the crude plant material as a whole, but the tests have not been made under strictly standardized conditions, either as to the strength of the drugs or as to the subjects on whom they were tried Nevertheless, certain physiological effects are sufficiently constant to be worthy of note, and these may be considered in relation to the organs of the body upon which they are most marked.

The general effects of peyote are a feeling of overfullness in the epigastric regions, a sense of heaviness in the head, and rapid respiration With larger doses, diarrhea and profound intoxication with a feeling of suffocation may be produced. The circulatory system responds at first with an increase in blood pressure and strength and volume of pulse, followed by a weakened rapid pulse, slowing heart and increased arterial tension These combined stages may take from eight to twenty-four hours or even longer

The physiological effect on the central nervous system is first one of exhilaration, excitement, and a sense of well-being. S. Weir Mitchell, in the *British Medical Journal* in 1896, described a "delicious languid sense of ease and elated sense of superiority." This is followed by a second stage of relaxation, depression and feeling of exhaustion, although with sleeplessness, unaccompanied, however, by any uneasy or restless feelings. If the dosage has been sufficient this stage may be followed by one of prolonged sleep.

In the first stage there is evidence of agitation, expressed in talkativeness and a desire to walk. The talk may become incoherent and confused In the second stage the pupils are widely dilated; there come an inclination to lie down and an incoordination of muscular action. The walk becomes irregular and staggering Muscular tremor is evident, especially in the outstretched fingers

The nerves of special senses are most affected This is accentuated in the sense of sight. Vision may be disturbed to an unbelievable extent. Those who have approached intoxication by peyote nearly always have illusions of brilliant hues following one another in rapid and peculiar succession, whether the eyes are open or closed The other special senses do not appear to be so much affected, although there is usually some disturbance of them all Havelock Ellis, another who in the early years of interest in peyote took an infusion of the drug, went through a first stage of exhilaration, which however passed quickly This was followed by heightened muscular irritability, faintness, difficulty in concentrating attention, singing in the ears, a vague sense of perfume in the air and color visions. All objects presented a heightened color, and vague shadows floated before the eyes, giving the room the appearance of a picture rather than of actual reality. The effects vary greatly with the individual, and visions tend to project the personality of the user.

Recent investigators also report two

PART OF A GROUP AT A PEYOTE CEREMONY IN THEIR CEREMONIAL TENT

PRESENT-DAY POLICIES MAKE NO ATTEMPT TO THWART TRIBAL CUSTOMS AND RELIGIOUS CEREMONIALS AS IN THE PAST, BUT GUARANTEE INDIANS THE RIGHT TO WORSHIP AS THEY PLEASE.

stages, the first sometimes described as one of mental contentment and exaggerated acuteness of certain senses, and the second as one of nervous calm and hypercerebrality, when thinking appears to be sharper and clearer During these stages consciousness is never lost although there may be extreme physical relaxation.

From all that is thus far known, peyote causes little if any moral or social degradation and, despite the claims of its antagonists, does not stimulate to acts of violence and is not aphrodisiac Some observers believe it dulls rather than excites sex feelings Indians claim that peyote cures drunkenness, and while there is some evidence in support of this, the truth probably is that the peyote cult creates a social situation in which drinking is undesirable. Some peyote groups actually prohibit the use of alcohol

One interesting aspect of the peyote cult today is that it is actually an Indian form of Christianity, this factor varying among the tribes. Christian hymns are often sung in meetings, and the Bible is sometimes seen on the altar with the fetish peyote Most important of all, the moral values of Christianity pervade the peyote cult, even though the form of the rite is still Indian Worship, humility and good will to men are greatly stressed, while Indian religious forms continue to exist. The Indian actually merges the two religions. He believes that the white man's God and his own are the same, but that each approaches him in his own way or by his own road. The white man has for this purpose Jesus, the Cross and the Bible, while the Indian has peyote. In this way the Indian does not destroy or belittle the white man's faith or his own. He has solved one important problem of the impact of the two civilizations.

Mention has been made of the function of peyote as a curing ceremony. It is

MEMBERS OF A PEYOTE CEREMONIAL GROUP SEATED AROUND A FIRE
A HALF-MOON ALTAR MODELED OUT OF EARTH IS VISIBLE IN THE FOREGROUND

also used as a specific remedy by many Indians for every conceivable illness and is even reported to have been used, in liquid effusion, as an antiseptic wash for open wounds. One writer reports the statement of a Kickapoo Indian that peyote is used "as white man uses aspirin." In spite of this constant, almost daily use that some Indians make of it, it is not habit-forming.

In most cases, doubtless, there is an important psychotherapeutic effect. The patient believes in the power of the god-plant as he feels it working on his body and his mind, and he knows also that the roomful of worshipers around him have combined the force of their minds on his recovery. Anxiety is dissolved and security increased, so that the body is unhampered to restore itself.

Physical illness of predominantly psychological origin often yields before peyote, as before other native curing ceremonies. Personal conflicts are more easily seen through, or psychoses exteriorized, under the cerebral stimulation of peyote. Some peyote users drink an infusion of the substance between meetings, when facing a difficult problem, in order to "sharpen one's mind." Self-searching is undoubtedly helped in the meetings by the sincere mood of the worshippers, the force of all the others bent on the same purpose, the mental concentration of the individual, and the perhaps hypnotic effect in these circumstances of the flickering fire, the rhythm of the drum and the moral suasion of the songs. Sometimes the suffering person himself, and sometimes another, suddenly sees through a situation which has been causing conflict, and the right thing to do is suddenly clear. The solution is considered to have come on the highest authority, for peyote is believed to be God's guidance, and the worshipers have faith in it. The peculiar physiological effect of the drug in enabling a person to see himself as if he were another person may also help in the auto-analysis. The confessions in public to the peyote god, and the repentance of individuals before the entire group, constitute a salutary practice, simplifying the mental states of the participants.

Those who would belittle the peyote

cult as not constituting a true religion overlook the fact that while the physiological effects of the drug are the basis of the faith, these effects are religiously interpreted. In the Indian mind peyote is the incarnation of the God spirit. Peyotism, moreover, is not too strange a form of religion Plant worship as such has existed in other times and places The incarnation of spirit force in something material like peyote also has its counterpart in the Christian religion, in the sacramental wine and consecrated wafer As far as a drug-taking religion is concerned, one anthropologist points out that the Zend Avesta, the sacred scriptures of the ancient Persians, which contain some of the loftiest thoughts of mankind, came out of that kind of a religion

Like the Ghost Dance, the peyote cult has given some internal strength to Indian groups that had become almost atomistic, scattered population pieces, without organization or coherence and without a point where governmental programs for economic betterment could take hold. One anthropologist reports that peyote has integrated one Indian reservation group in just this way.

This strengthening has happened not only within groups but also between different tribes Where formerly intertribal rivalry and even war prevailed, the Ghost Dance and now the peyote cult have brought about intertribal relations instead. There is an organized intertribal peyote religion, incorporated legally in Oklahoma and South Dakota as the Native American Church. Common symbols on jewelry and clothing worn by peyote people are an expression of their oneness, and there is no distinction by tribe.

For those who fear the peyote cult, this summary can be made. Peyote use has been confused with some existing evils, but it does not represent such an evil in itself, in the opinion of the best experts Most important of all is the social significance of the cult, which anthropologists can explain but which the casual observer must miss Further, there is the probability that the peyote cult forms only a passing phase in modern Indian life It has shown a tendency to fade out in the early part of its trail, or lose its great significance, perhaps because it too, like the Ghost Dance, fails in the end to fulfill its promise But the peyote cult has offered the Indian an assuring foothold for a moment, when he needed it, in the changing world.

SWEDEN LOOKS TO ITS AGRICULTURE

By EWERT ÅBERG

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SWEDEN, one of a few small nations in Europe that is still neutral, has occasion to worry about food production as well as defense When the people of Sweden, in 1938, realized that war was developing in Europe they knew that isolation, far worse than was their lot in the first world war, was coming However, the nation was much better prepared for farm production during a period of isolation than during the last world war. This more favorable condition may be attributed to the intensive work in soil, farm crops and animal husbandry and to the rapid development in plant breeding Equally important during a crisis like the present are youth movements among the farmers and cooperative farm associations, which are widely spread in Sweden These organizations have educated the farmers so they are eager for advice and suggestions as to how they can cooperate with one another and with government agencies—both tremendously important at the present time [1]

Being located far to the north, Sweden does not have the climate or the lands particularly favorable to farming Only 9 per cent. of the total land area, or 9,312,000 acres, are cultivated. In spite

[1] Åberg, Ewert, "Solving Farm Problems in Blockaded Sweden," *The American Swedish Monthly*, 1941. Vol 35, No 12, p. 11.

"Sweden adjusts its agriculture to war conditions," *Foreign Agriculture*, U. S Dept of Agriculture, Washington, D C, 1942 Vol 6, No 1, p. 3

"How Sweden Feeds Herself," *American Scandinavian Review*, 1942, p 60.

FIG 1. A TYPICAL WINTER WHEAT FIELD IN SOUTH SWEDEN*

* Figs. 1, 2, 4, 5, 6, courtesy the Swedish Travel Information Bureau, Inc., New York.

FIG. 2 MAIN BUILDING OF THE PLANT BREEDING STATION AT SVALOF

of this the goal of Swedish agriculture is to bring the total farm production high enough to make Sweden independent of importation of farm products. In this work the agricultural experiment stations, during the last twenty-five to thirty years, have labored arduously to obtain ways and means to reach this goal.

The soil of Sweden needs much careful attention. Drainage of the soil was introduced early and today most farms are drained satisfactorily. The Swedish soils need complete fertilizers, i.e., nitrogen, phosphorus, potash and lime, for the production of good crops For a long time the experiment stations and the local agricultural associations have conducted field experiments to determine fertilizer needs Since most of the fertilizers normally are imported to the country, it is very important that they be used as efficiently as possible and applied only where they are absolutely needed. This can be done if each farmer has a map of his fields showing the state of fertility. It is, however, too expensive to make maps for each farm on the basis of fertilizer experiments. Therefore the present system is to use chemical analysis of the soil or of the plants grown Maps of the individual farms are then based on the chemical analysis and they indicate where fertilizers should be used and the amounts that should be applied This "soil mapping method" has been introduced recently. Plans for drainage, the application of fertilizers and cultivation methods with modern machinery are important preparations for growing crops according to new methods of farming.

The old type of farming was mainly based on the production of rye, barley, oats and wheat, and of grasses and clovers for hay or pastures. As the soils were improved new plants came into the picture. Potatoes were introduced late as compared with the cereals and grasses; sugar beets were still later. Oil- and protein-plants were the latest introductions and were never considered important before the war brought isolation. When the importation of proteins and fats was cut off the Swedes began to understand that the growing of oil- and protein-plants was vital to the nation, and was of the same importance as the growing of wheat, potatoes and sugar beets. Of the protein plants used for direct human consumption, only yellow

peas and to a certain extent kidney beans were grown extensively enough before the present war to be considered important Oil- and protein-plants for industry or for fodder, such as soybeans, seed-flax, sweet lupine and poppies, were hardly heard of before the present isolation.

With new plants and with better farming practices, increased yields were natural. The total yield of wheat in 1938 was more than three times higher than the average yield in 1911–1915, while the total yield of rye in 1938 was three fourths of the average yield in 1911–1915. A shift from rye to wheat has taken place The total bread cereal production in 1938 was 1,226,000 tons, as compared to 853,000 tons in 1911–1915 and to 570,000 tons in 1871–1875 The yield in 1938 was high enough to make Sweden self-sufficient with bread cereals The high bread cereal production in recent years is dependent not only on an increase in lands used for wheat but also, and very much so, on the increase in yields per acre. Winter wheat yielded thirty-eight bushels per acre in 1938, compared with nineteen bushels in 1871–1875; for spring wheat the figures were twenty-seven and eighteen bushels, respectively, and for rye, twenty-seven and eighteen bushels With sugar beets and potatoes similar results have been obtained Since 1913 the sugar beet production has been doubled and was estimated to be 2,035,000 tons in 1941 and 1,750,000 tons in 1942. The yield of potatoes was reported to be 2,072,000 tons in 1941 and 1,800,000 tons in 1942 The per acre yield of potatoes had increased from 106 bushels in 1871–1875 to 180 in 1938. Sufficient amounts of both potatoes and sugar beets are produced at the present time to supply the nation's needs.

However, this is not the case with feed grains, for barley and oats have in many places been replaced with bread cereal, and the increases in yields per acre, although high, are not enough to make the total yield of feed grain sufficient for the nation's need. In 1871–1875 the yield of barley was nineteen bushels per acre, in 1938, thirty-two bushels; for oats

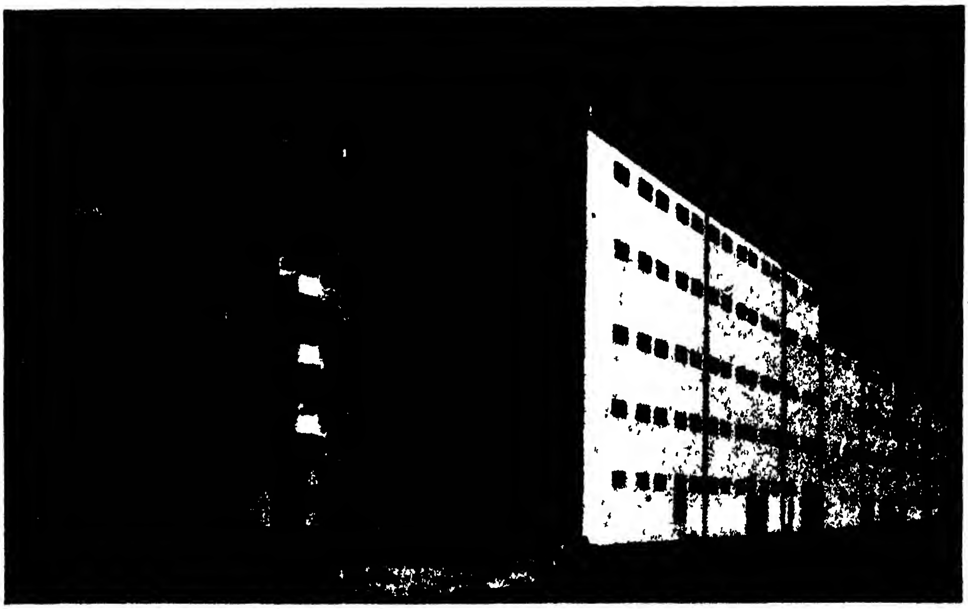

FIG. 3. SEEDHOUSE, WEIBULLSHOLM PLANT BREEDING STATION

the respective figures were seventeen and twenty-seven bushels Importation of corn and small grains for fodder is necessary and this is true also for protein- and oil-cake for cattle feeding High increases in the total production of grasses and clovers for hay or grazing purposes have been obtained It is estimated that the annual average feed units from forage crops during the five-year period, 1931–1935, was 3,920 million, which is 44 per cent. of the total feed units produced annually in Sweden during that period Further increases are both possible and necessary

The increases in yields of different crops during the last century can be credited to two lines of work · plant breeding and better cultivation and handling of crops Plant breeding started with small grains and root crops about fifty years ago The main plant breeding work is now carried out at Svalof and at Weibullsholm Important varieties of grain, such as *Victory* oats, *Standard* winter wheat and *Golden* barley, have been bred at Svalof and Weibullsholm These varieties have been tremendously important in increasing the per acre yield not only in Sweden but also in large areas over the rest of the world. In the summer of 1941 fields of Victory oats in the United States proved that it really takes a long time to breed varieties that surpass them in yields Victory oats were released more than thirty years ago. Standard wheat and Golden barley released twenty or thirty years ago, are still used in some areas in Sweden. Other important varieties have been bred; examples of some of the more recent ones are the following: Winter wheat—*Skandia II, Aring III, Gluten, Ankar II, Ergo, Sun IV, Gyllen II* and *Jarl;* oats—*Bambu, Sun* and *Eagle;* barley—*Freja, Balder, Edda, Puke II* and *Dore;* and spring wheat—*Atle* and *Diamond II.* The type of wheat that is used and to which the mentioned varieties belong is shown in Fig. 1.

At the present time there is in Sweden a very intensive breeding program with forage grasses and clovers Most of the strains on the market today are results of selection, and the advantage of local strains is very important, particularly in the case of red clover, Sweden's number one legume for meadows (Fig. 4). Importation of red clover seed from continental Europe has been abandoned and the advice to the farmers is now · "Buy your seed from your local district or produce it on your own farm" This is true also for seeds of plants other than the red clover Sugar beet seed is now produced in Sweden instead of being bought from Germany. The Swedish Sugar Company has its own plant breeding station at Hilleshög, Landskrona. There is perhaps no other country in the world which can show as definite results of the importance of right varieties or strains in the right place The use of correct varieties is closely dependent on a reliable seed trade It is then easy to understand why the seed certification has developed rapidly. With as many new varieties of cultivated plants as there are in Sweden, there is a real need for a certification system that guarantees that the farmers get the correct varieties. If they do not, it means extensive losses for the farmers as well as for the nation.

Research workers have studied the methods for growing the plants produced by the plant breeders In addition to being dependent on the improvement of the soil, as discussed earlier, the increases in yields per acre are dependent on better seeding, harvesting and drying methods Regular crop rotations are generally followed. They include fallow, small grains, root crops, legumes and hay meadows The use of these regular rotations prevent depletion of the soil and increase the per acre yield of the plants The important gains of fodder that have been secured from pastures and hay meadows depend on a number of factors. The meadows are most often

seeded with early small grain as a nurse crop and the clovers and grasses are drilled, which is also the case with grasses and clovers for pasture. No nurse crop is used, however, for seeding the pastures. The old method of broadcasting the seed in fall-sown nurse crops has been almost entirely abandoned. Rotational grazing of the pastures is absolutely necessary for establishing a good stand. Blue grasses, rye grasses, timothy, fescues, redtop and white clover are the most common pasture species

The pastures along with hay production have made it possible to increase the livestock and bring dairy production up to its present high standard. The pastures are especially important for the dairy production in middle Sweden. The cattle used there are the Swedish Red and White The cows average 1,150 pounds in weight and produce about 8,800 pounds of milk per year with an average butter fat content of four per cent In the southern parts of Sweden the heavier Swedish Friesians are popular (Fig. 5). These cows weigh about 1,325 pounds and they give about 11,000 pounds of milk with 3.5 per cent. butter fat. Before the war butter was one of Sweden's most important farm products for exportation In 1939, 3,200,000 tons of milk were delivered to the creameries, which meant an increase of almost three times that of the 1913–1915 average when 1,214,000 tons were delivered. In 1939 Sweden produced 184 million pounds of butter and 96 million pounds of cheese.

The increase of livestock resulted not only in a higher production of dairy products but also in a higher production of meat Need of cooperative associations for solving marketing problems for dairy products and meat arose and the "Swedish Dairies Association" and the "Swedish Federation of Meat Marketing Societies" were organized in 1932 and in 1933, respectively. They have been followed by a number of other organizations and at the present time every farmer is a member of some cooperative organization. The cooperative associations,

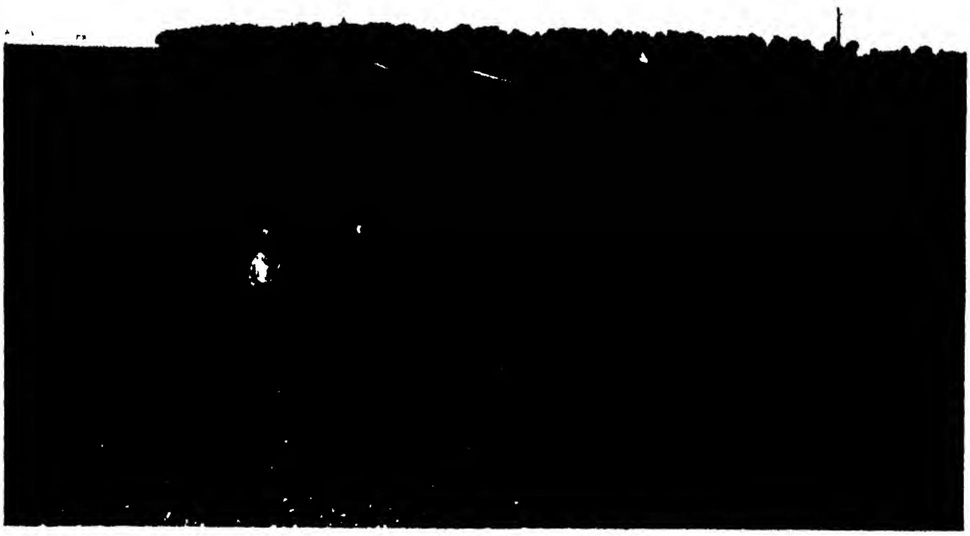

FIG 4 A RED CLOVER FIELD IN SOUTH SWEDEN
THE MOST IMPORTANT LEGUME IN THE SWEDISH MEADOWS IS RED CLOVER.

FIG. 5 CATTLE GRAZING IN SOUTH SWEDEN

through meetings, shows, journals and the radio, have helped to educate the farmers in fields where the schools have left off When the war began in Europe and the isolation of Sweden became a fact, Swedish farmers were organized in cooperative associations and ready to do what they could to produce enough food for the nation. They were also ready and willing to adapt new methods for farming, as well as to try farming under extreme conditions

With a development of the agriculture in a democratic nation like Sweden, it was only natural that the Government should pick a group of men representing research work and farming to form a committee for solving important food production problems This was done in the fall of 1938. The main thing the men of the committee did before the war started in 1939, and before the complete blockade of Sweden came in the spring of 1940, was to arrange for the storage of certain foods, livestock feeds, fertilizers, gasoline and oil. They planned and organized an increased production of a number of foods inside Sweden. If the weather conditions had been normal there would have been only one real big farming problem during the isolation: *the production of fat and protein.* Extremely low yields of 1940 and 1941, resulting from cold winters and dry summers, changed the conditions so much that there is now, in addition to greater difficulties in producing fats and proteins, also difficulties in producing enough bread cereals. Fiber and rubber are also on the list of badly needed plant products Consequently the farmers are now faced with problems of increasing the production of oil and protein plants, sugar and starch plants, fiber plants and rubber plants

It may seem almost impossible to suddenly increase this production in a nation where the farmers are already using a regular crop rotation system and where every acre of soil that can economically be used is under cultivation There is no other possibility than to cut down on some of the less important and low yielding crops and to use the lands so obtained for crops which are vital for the nation's food situation. And that is also what has happened. The acreage of sugar beets, wheat, and rye is increased by abandoning the fallow and by avoiding the use of meadows for more than two years in the crop rotation. In a number of places the meadows are normally used for four or five years. The yield after two years of meadow is, how-

ever, too low to compete in feed units with the yield from a wheat crop. Wheat has replaced oats to a certain extent because of its higher food value. To further promote the increased growing of bread cereals, a part of the price of the wheat and rye is paid in the form of a bonus per acre seeded to these crops.

Protein and fat production are increased in two ways. It is easiest done by taking still better care of the grasses and legumes in the pastures and meadows. There the use of right varieties or strains is coming into the picture Also the curing of hay is very important and it is estimated that about half of the feeding value in the concentrate feeds, normally imported to Sweden, could be obtained by using drying methods that quickly reduce the moisture content of the plants so that storage can be safely made Still more can be obtained by artificial drying in electric driers. This method, which came to Sweden from England five or six years ago, is still in the experimental stage. The increase in feeding value of the dry product compared with the feeding value of field-dried hay is, however, so great that, with the cheap electricity in Sweden, it will be possible to develop the method to economic practicability. The moisture content is reduced to 10 per cent. by drying the forage crops at 250° Centigrade for ten minutes. The dry product is considered at least twice as valuable as that gotten from usual field curing methods. Since the isolation the use of silage became more common It appeared to be the best method of preserving certain products that normally are fed green or are not used for fodder. Silage is, for example, made from potato-tops, sugar-beet-tops and grasses from lawns in the cases where the lawn grasses are not allowed to grow high enough to be cured for hay The A I V. method, named after Professor Arthuri I. Virtanen in Helsinki, is now being used in the preservation of forages. In the process the green material is preserved by adding sufficient dilute mineral acids (sulphuric

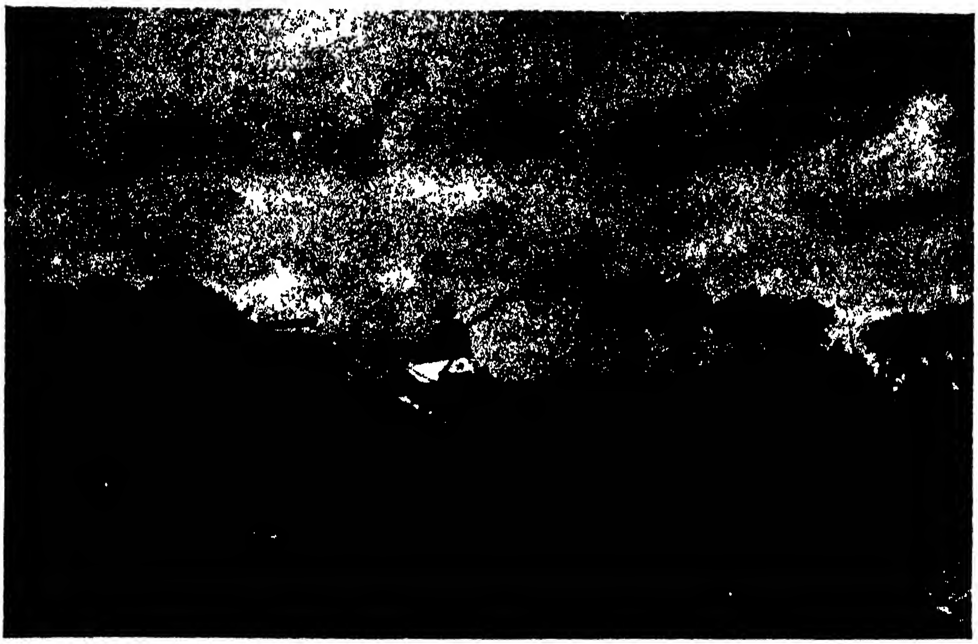

FIG. 6. HORSEPOWER IS AGAIN IMPORTANT IN SWEDISH AGRICULTURE

and hydrochloric) at the time of packing the material into the silo.

The protein products derived from grasses and clovers are not enough, as their main value is feed for the livestock Only indirectly do they influence the fat and protein supply for direct human consumption The production of oil and protein plants yielding fat and proteins for direct human consumption have been tried with diverging results. Yellow peas and kidney beans are well adapted for Swedish conditions Boiled yellow peas have always been a standard dish for Swedish homes and are now more important than ever. They are badly needed for the Swedish army at the present time. A number of good varieties are available and the area given over to peas has been increased since the beginning of the war Kidney beans are as well adapted to Sweden as yellow peas, but before the isolation were grown mostly in gardens Now they are being produced successfully in field quantities Soybeans were introduced in order to get the oil for certain industries, but they are not very well adapted to the cold climate and the short growing season Intensive breeding of soybeans is therefore a necessity, and that is true also for other new oil plants such as seed flax, rape, sweet lupine and poppies But even if these new oil plants are not well adapted for Swedish conditions, the area given over to them in 1942 was about 45,000 acres. The area for increased production of oil and protein plants was obtained mainly by cutting down the area in oats.

Flax and hemp were grown during earlier periods as fiber plants but were rare when the present isolation came. However, the area used for them has been rapidly increased and during 1942 about 5,000 acres of flax and 2,500 acres of hemp were seeded. This means that about one fourth of the need of flax and

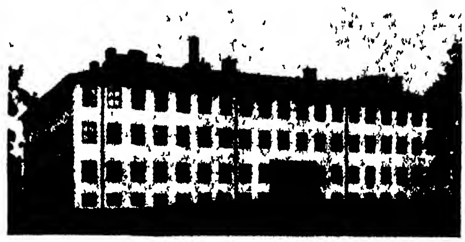

FIG 7 AGRICULTURAL COLLEGE
ONE OF THE BUILDINGS AT THE COLLEGE LOCATED AT UPPSALA, THE CENTER FOR AGRICULTURAL EDUCATION IN SWEDEN

almost the total need of hemp was covered by domestic production in 1942

The only rubber plant that seems to have any future in Sweden is the Siberian dandelion, or kok-saghyz Experiments with this plant were started in the spring of 1942 and definite results can not be given at this time. However, if the normal need of rubber in Sweden should be obtained only from kok-saghyz, an area of 240,000 acres would be necessary

The introduction of new plants and of new farming methods necessarily brings up the need for more labor. As the greater number of the farms in Sweden are small, there is much need for hand labor Necessary calls of young men to the army were expected to upset the farm production program The difficulties have been overcome by organization of cooperative "labor units." The idea is to group a number of small farms into one unit and select one of the men on these farms as the leader of the unit If necessary all available men, horses and machinery can be placed under his command. This makes it possible to get more work done than when every farmer does his own work on his own farm. The women have also declared their willingness to help the farmers by organizing committees for training the women in farm work and for distributing available trained women laborers to farmers.

FIG. 8. TRACTOR
BUILT FOR DRIVING WITH CHARCOAL OR WOOD.

The shortage of gasoline, kerosene and oil for the operation of tractor driven machines appeared to have limited the use of tractors when isolation of Sweden first occurred But now the tractors are driven by gas generated from charcoal or wood The gas is produced in stove-like generators, placed on the side of the tractors (Fig. 8) Charcoal or wood is burned in these generators and the important products in the obtained "gengas" is carbonmonoxide (CO) and hydrogen (H_2). "Gengas" from charcoal contains about thirty per cent carbonmonoxide and twelve per cent hydrogen, and "gengas" from wood contains about twenty-two per cent and eighteen per cent, respectively. Even if the efficiency of the motor is cut to thirty or forty per cent., as compared with the efficiency with the use of gasoline or kerosene, the results are satisfactory to the farmers. At the beginning of 1942 it was estimated that 5,000 tractors had been rebuilt for use of "gengas," which is about twenty-five per cent of all Swedish tractors.

Without a rationing system there would not by this time have been food enough for all the Swedish people. The rationing was introduced during an early stage in the isolation period and is extended now so that the only farm products not yet rationed are milk, vegetables and potatoes. Besides rationing, other steps have been taken to secure enough food of which the following are examples. Since November 1941 the milk for consumption was standardized to contain 3 per cent butterfat in order to obtain enough fat for a normal butter production In April 1942 the milk production had decreased twenty-six per cent of that in 1939, while the butter production had decreased about twenty per cent. About 800,000 tons of bread cereal were needed for flour production during 1941–1942 and the yield of wheat and rye was 620,000 tons in 1941, which is 55–60 per cent of normal yield To these 620,000 tons there were added 60,000 tons stored from the wheat crops of 1938 and 1939. Furthermore, 40,000 tons of barley and 15,000 tons of potato starch were mixed with the wheat There was then a shortage of 65,000 tons, which was compensated for by using the whole wheat flour. The barley for mixing with the bread cereal was obtained by cutting down by 80 per cent. the amount of barley for brewing and distilling. In 1942 the yield of bread cereal is estimated to be about 965,000 tons, which is about ten per cent below the normal yield. But this yield makes the situation brighter for 1942–1943 as far as bread and flour are concerned It is, however, likely that a certain amount of the 1942 crop will be stored as a reserve in case the 1943 yield is low.

It is quite obvious that price increases of the farm products are necessary if the farmers are to continue production under the conditions as discussed here. But it is also necessary to keep the consumer-prices as nearly normal as possible The Swedish Government takes the responsibility for the difference between the farmers' and the consumers' prices by paying a bonus to the manufacturers as, for example, to the creameries and millers. As almost all creameries are organized in one cooperative association the support to them is paid through this

association. Once again the advantage of the cooperative associations during the present crisis is demonstrated The price control on farm products in Sweden seems in most cases to follow the principle of getting by taxes the money that is needed for standardizing the prices so that they satisfy both the producer and the consumer The average price increases are not very high In August 1942 the total living cost in Sweden was forty-six per cent higher than in August 1939

It is hard to say what will be the best lesson obtained from the isolation But it is quite clear that the production of fats, and proteins and fiber will be increased in an attempt to make Sweden self-sufficient for these products. Still more important is the result that the whole crop production program will be based on the idea of producing necessary foods and other essential crops This means an adjustment of the farming conditions from year to year. The agriculture will have to be a dynamic one, which is only possible with intelligent, well-educated farmers and laborers They are needed in the future farming and they will no doubt be found if the present school system and youth movement programs continue to work With the cooperative associations' help, every man in farming will be better able to understand his own vital importance and his responsibility in the community. As he does so he will be able to do his part of the work much better This will mean a step towards a still better agriculture in Sweden

THE ROLE OF PETROLEUM IN THE MIDDLE EAST

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THE geographical triangle, lying within the boundaries that join the Mediterranean, Black Sea and Indian Ocean, vaguely known as the Middle East, is the crossroads of the Old World This region contains the gateway to three continents, the entrance to southern Europe through the Vardar Valley of the Balkans, the overland route to India by way of Baluchistan, the backdoor to Russia through Iran, and the principal route to central Africa by way of the Nile River. However, the Middle East is not only important from a purely strategic point of view but also has many natural resources that are vital to a war economy. In area the Middle East is almost as large as the United States, but has little more than half the population. Today about ninety per cent of the people are dependent for their existence on agricultural pursuits. Nevertheless, only eighty thousand of the total of two million five hundred thousand square miles are devoted to crops, about twice that to grazing, and some seventy thousand square miles to forests. The remainder, about eighty-eight per cent., is desert, fen or barren mountains

Although agricultural resources are greatly limited, this area contains patches of exceedingly productive land in the irrigated sections of Palestine and Syria, on the alluvial plains of the Tigris, Euphrates and Nile Rivers, and in a number of the desert oases of Arabia. Of the various cereal crops, wheat, barley, rice and millet are most widely cultivated. Other agricultural commodities are cotton, dates, tobacco, olive oil, fruits, nuts and wool. Of these, dates, cotton, tobacco and wool products are important in international trade.

Although the Middle East is moderately rich in mineral resources, development has lagged, mainly because of poor transportation facilities, long distance from market, and the lack of coal for smelting purposes There are considerable deposits of chromium, iron, manganese, copper, zinc, antimony, lead, silver, gold and mercury. However, from a military viewpoint, the richest prize of the Middle East is the vast petroleum resources of Iran, Iraq, Saudi Arabia, Bahrein Island and Egypt The exploitation and refining of petroleum is the most important mineral industry of the region. Because of the international significance of petroleum, it exerts an important influence on the economy of the Middle East. Today this industry has greater importance than at any time in the past, for the United Nations are dependent upon the oil resources of this region to supply with fighting fuel many of the battle areas of the world. The loss of these oil fields would not only give a source of oil to the enemy but also would relegate the Allied Nations to complete dependence on petroleum from the Americas.

IRAN

Mineral oil from seepages in Iran was collected as early as 500 B C. and at the time of Herodotus its uses ranged from the making of mummies to the waterproofing of cisterns, silos and ships' hulls; binding of building blocks in Babylon, and application in the arts of the painter and apothecary. However,

it was not until 1901 that the first concession for the exploitation of oil was granted in Iran. It was made to an English adventurer, D'Arcy, for a period of sixty years and included all of Iran except the five northern provinces that came under the influence of Russia. At this date it was exceedingly difficult to transport drilling equipment in the country, for there were no railroads, and north of Baghdad no waterways were navigable. The work of drilling was equally difficult, but in 1903 oil was discovered near Chiah Surk close to the Perso-Turkish boundary. Because of the lack of transportation and the limited amount of oil, development lagged. In 1908 large quantities of oil were discovered near Masjid-i-Sulaiman in southern Iran, and in 1909 the Anglo-Iranian Oil Company was organized. It required three years to develop commercial production and to lay a pipe line to the Persian Gulf. The first crude oil was exported in May, 1912, and a refinery was constructed at Abadan early in 1913 The British Admiralty owned most of the shares of the Anglo-Iranian Oil Company, and during World War I there was a grim struggle for control of the field and the pipe line to the coast.

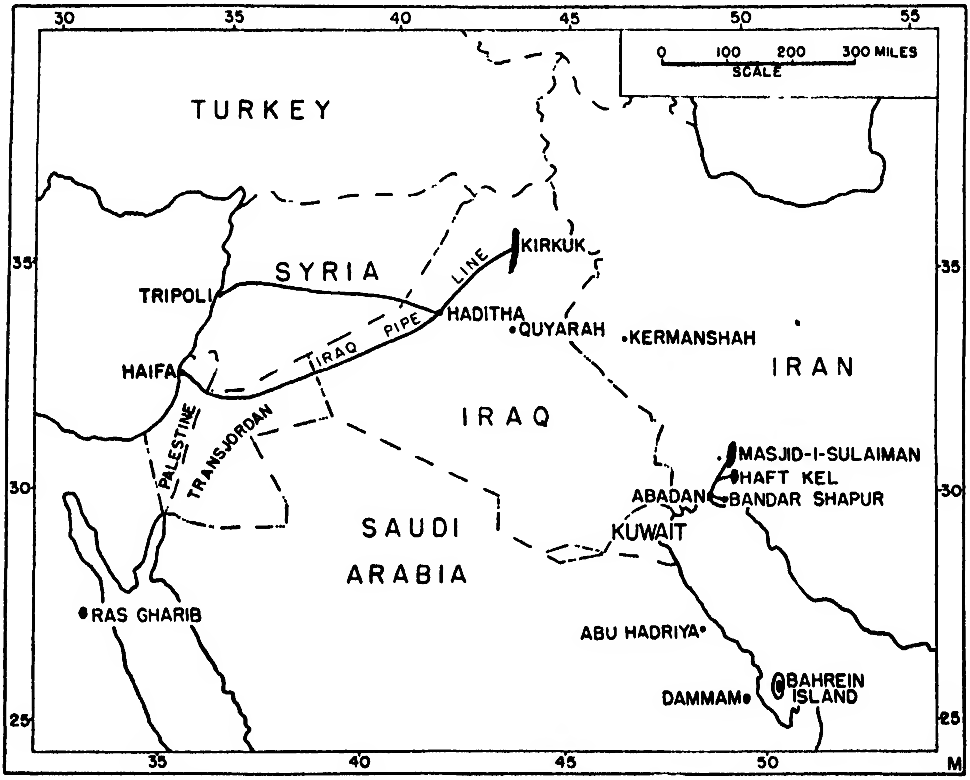


FIG. 1. REGIONAL LOCATION OF THE OIL FIELDS WITH THE MAJOR PIPE LINES OF THE MIDDLE EAST.

Exploitation of the oil resources proceeded slowly on a prorated production schedule during the 1920's. In 1932, as a result of the growth of nationalistic policies in Iran and the aim to eliminate foreign influence, the Shah of Persia cancelled all foreign oil concessions. The dispute was placed before the League of Nations. The concessions were adjusted

to be legally binding for another sixty years, but the Anglo-Iranian Oil Company had to pay a fixed price for each acre of concession and a twenty per cent. royalty fee on each barrel of oil produced instead of the previous sixteen per cent net profit The treaty also provided for a progressive Iranization of the oil workers Finally, before the end of 1938 the Company had to choose from the original concession one hundred thousand square miles to be the actual field of development while the remainder reverted to the Iranian government

The oil districts in Iran are considered to be among the richest in the world. The southern fields of Masjid-i-Sulaiman and Haft Kel are the largest producing fields in the country and are both connected by pipe line to Abadan Other fields in southern Iran at Lali, Agha Jari and Gatch Saran have been developed with excellent potential output. The oil formations are twenty-five hundred to six thousand feet deep, and the crude is around 37° gravity—A P I. The northern fields of Naft-i-Shad and White Oil Springs are considerably smaller than those in the south In 1940 there were seventy-five wells in the country with a restricted production of 131,000 barrels a day Iran in 1940 was the largest producer of oil in the Middle East and the fifth largest producer in the world, with a production of 78,592,000 barrels.

At Abadan one of the world's largest refineries is located This modern refinery has capacity to process 280,000 barrels of petroleum a day. The production of high octane aviation gasoline began in 1931, and the "cracking" facilities are now 125,000 barrels a day The storage facilities amount to about six million barrels in the form of seventy thousand-barrel tanks located on two large tank farms. Two oil-loading jetties for deep-sea tankers have been built along the Abadan-Bavarda shore, in addition to a quay 1,350 feet long. There are also several jetties for loading barges with oil for shipment on the Euphrates, Tigris and Karun River systems.

A second refinery in Iran, located at Bandar Shapur on the Persian Gulf, has a daily capacity of fifty thousand barrels It also gets its oil from Masjid-i-Sulaiman and Haft Kel. The refinery has facilities for producing thirty thousand barrels daily of high octane gasoline The petroleum in northern Iran is refined at Kermanshah The refinery capacity is small, around three thousand barrels a day, and the products are consumed locally

Iraq

The securing of concessions for the exploitation of the Iraquan oil fields has an interesting history The first grant was given prior to World War I to the Anatolian Railway Company (a German company associated with the Berlin to Baghdad railroad enterprise) The concession was not clearly confirmed by the Turkish government, and another company under British control also obtained a concession During the war, control of the Anatolian Railway Company passed into British hands, and along with it went whatever rights may have existed in the company's oil concessions

After World War I, since the Ottoman Empire was no longer in existence, a struggle ensued over the validity of the British concession and the national ownership of the oil districts. The League of Nations finally assigned the oil fields to Iraq, and the Iraq Petroleum Company was organized (familiarly known as the I P.C.). Ownership of the I P.C. is divided between the Anglo-Iranian Oil Company, Anglo-Saxon Petroleum (owned by the Royal Dutch Shell interests), Cie Française de Petroles, and the Near East Development Company (owned jointly by Standard Oil of New Jersey and Socony Vacuum).

Each of these participants owns 23.75 per cent. A private individual, an original concessionaire, owns the remaining five per cent.

The development of the oil districts in Iraq was retarded greatly because of the lack of transportation facilities for the crude oil. The completion of the fifty million dollar Iraq Pipe Line in 1935 was the first impetus to extensive exploitation Production increased from seven million barrels in 1934 to twenty-seven million barrels in 1935 The pipe line starts at Kirkuk and runs to Haditha where it bifurcates, one branch extending to Haifa in Palestine and the other to Tripoli in Syria. It is 1,150 miles long and has an annual capacity of about twenty-eight million barrels The construction of this pipe line was one of the greatest engineering feats in the Middle East Extreme heat and cold, rugged terrain, swiftly flowing mountain streams, and laying pipe through lava beds all contributed to the hardships of construction

The major producing field in Iraq is at Kirkuk It is about sixty-five miles long and has an average width of about two miles Sixty wells have been drilled in the productive area. Many of them have a production of ten thousand barrels a day but are restricted in output to conform to market conditions The Kirkuk crude is around 36° gravity A P I (a fairly good grade) and is produced from formations 2,100 to 2,200 feet deep The field has been developed as a unit operation employing modern scientific methods.

Seventy miles south of Kirkuk, on the banks of the Tigris River, the Quyarah field is located It has a potentially great production, but the crude oil is of so poor quality that output is greatly restricted The oil is used only for local fuel and road oil requirements. There is also a small producing center near Naft Khaneh on the Iranian border.

There are no large complete refineries in Iraq However, before the crude is pumped through the Iraq Pipe Line it is treated in a stabilization plant at Kirkuk, which is designed to remove the high content of hydrogen sulphide. The stabilization plant has a capacity of about one hundred thousand barrels a day It can produce low octane gasoline but does not produce kerosene or high octane aviation fuel. At the terminus of the pipe line at Haifa the British have

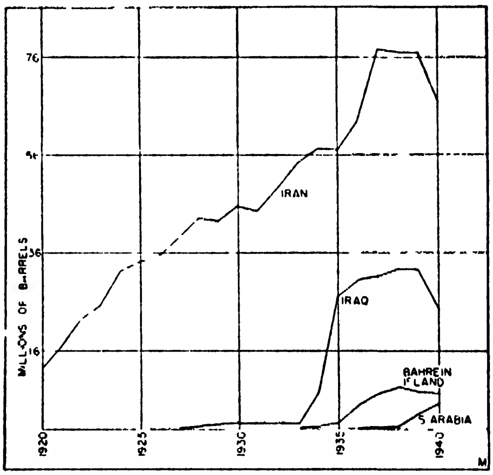


FIG 2 PRODUCTION OF PEROLEUM FROM 1920 TO 1940 IN THE MIDDLE EAST

constructed a refinery of forty thousand barrels daily capacity At Tripoli there is only a loading dock. Within Iraq the production from Naft Khaneh and Chia Surkh is refined at Khanaquira (Aldwan). The refinery here has a capacity of about 2,500 barrels per day.

Saudi Arabia

The first oil concessions were granted in Saudi Arabia in 1935 to the Standard Oil Company of California, and geological exploration began immediately The grant is located in El Hasa and has an area of 249,000 square miles, the approximate combined size of California and Oregon. After a number of wild-

cat wells were drilled, oil was discovered in 1936. The Dammam field is surrounded by desert, but as a result of abundant springs it has a number of magnificent oases. The greatest handicaps to the development of the field have been inadequate outlets and refinery facilities. On January 1, 1942, there were sixteen producing wells, with a daily potential yield of seven thousand barrels The oil ranges from 35 to 50° A.P.I gravity and comes from depths varying from 2,100 to 8,000 feet. Production has risen from a yearly total of twenty thousand barrels in 1936 to over five million barrels in 1941

Test wells have yielded favorable returns in three other districts of Saudi Arabia The Abu Hadriya district and the Maagola area about one hundred miles northwest of Dammam have given promising indications. The first well drilled in the Kingdom of Kuwait had a potential production of approximately 4,400 barrels a day from a depth of 3,500 feet Production in each of these areas is shut in and development will begin only after pipe line and refinery facilities are constructed. With these facilities available production can be greatly increased

Bahrein Island

Bahrein Island, for centuries renowned for its important pearl fisheries, has now become the center of a well-developed oil industry. Active exploration first began on Bahrein Island in 1932 after the Standard Oil Company of California had acquired the exploratory rights The first well was completed in June 1932, producing 2,400 barrels daily at a depth of 2,008 feet. However, the first shipment of crude oil was not made until 1934 By 1936 sufficient production had been developed to demonstrate that the field was capable of sustained production over a large area, and in 1937 the drilling program was changed from straight exploration to partial development. The wells are large, a number having a potential production of twenty thousand to thirty thousand barrels a day. In recent years output has been restricted because of insufficient refinery capacity and inadequate transportation facilities Only enough has been developed to supply the anticipated immediate demand for petroleum and to maintain a gas-oil ratio likely to give the maximum ultimate production rather than the maximum present production. The highest production came in 1938, with a yield of 8,298,000 barrels Since the beginning of World War II many of the markets of Bahrein petroleum have been lost, so that production has fallen off considerably. Much work has been done on a repressuring system, and the arrangement of the compressors, controls and other features designed to thwart invasion will help to guard the oil resources of the field. Since the Sheik of Bahrein is assisted by a British political adviser, this territory has been bombed by Italian aircraft a number of times.

Construction of a refinery was begun in 1935 as soon as it was evident that production would justify the operation of a plant Originally designed for ten thousand barrels daily capacity, the refinery facilities have been enlarged so that at present it has a daily capacity of 32,500 barrels. To aid in handling the refined oils a loading terminal was constructed on Sitrah Island, a short distance from the main island across shallow water. Pipe line connections run from the refinery to the terminal. At low tide the wharf will accommodate two tankers. The daily loading capacity ranges from 1,600 to 4,800 barrels, depending upon the product.

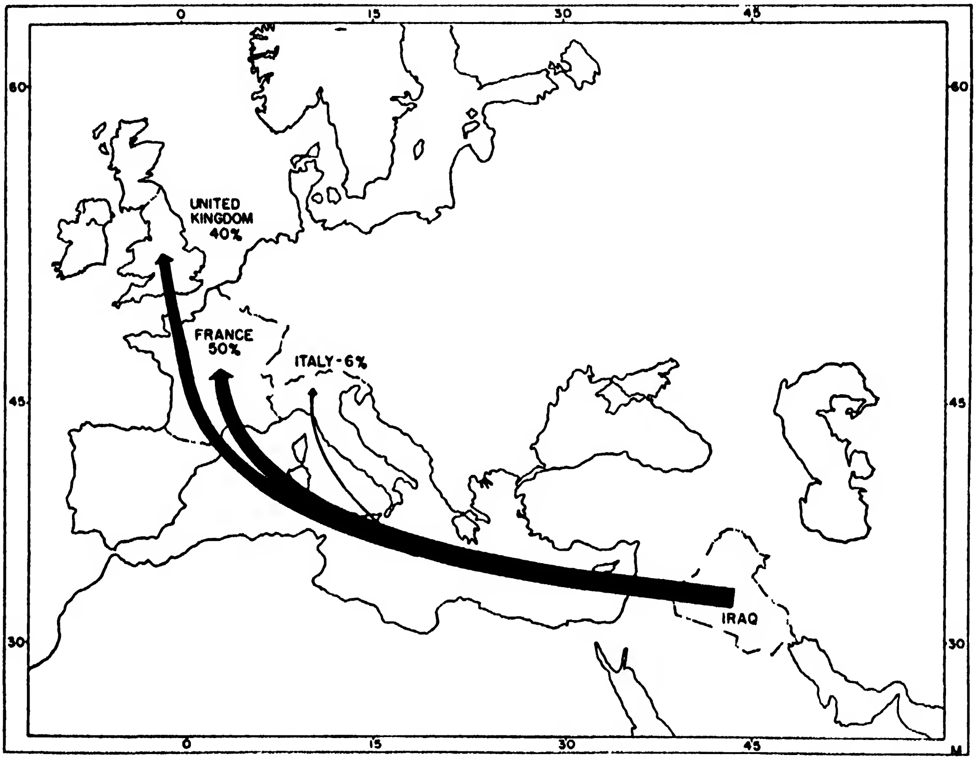
Egypt

Petroleum in commercial quantities was discovered in Egypt in 1911 at Hurghada, about two hundred and fifty miles south of Suez. Because of strin-

gent mineral laws there was little incentive for additional exploration or development, and so production remained small, usually under a million barrels a year. Finally, in 1936 the petroleum laws were liberalized, and both American and British companies increased their exploratory efforts. As a result in 1938 the Ras Gharib field, about midway between Suez and Hurghada, was discovered. Production in 1939 was 5,100,000 barrels,[*] an increase of 207.19 per cent. above 1938. With the outbreak of the European War in 1939, a decline in output was caused by interruptions of tanker schedules, delay in delivery of equipment, and restrictions on civilian consumption in a number of countries served by Egypt. However, with the beginning of hostilities in North Africa this became the nearest source of petroleum and production increased Two refineries located at Suez, one of seventeen thousand barrels daily capacity and the other fourteen thousand barrels, process the Egyptian oil.

Markets of Middle Eastern Petroleum

Since the Middle East consumes only a small percentage of its total production, most of its petroleum must be exported. Production has always been controlled by market demands. In 1940 more than ninety per cent. of the oil of this region entered international trade. Petroleum-deficient Europe is normally the largest consumer of Middle Eastern petroleum, usually taking more than seventy-five per cent. of the total export.



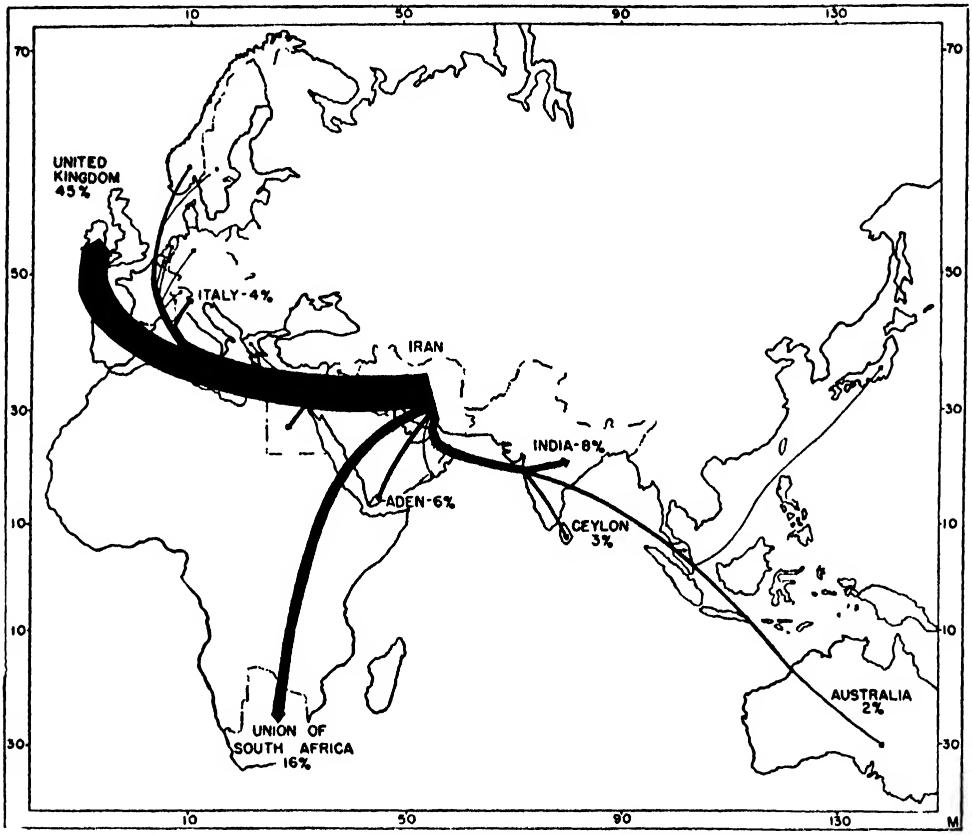
International Petroleum Trade, U S Department of Interior

FIG. 3. PRINCIPAL MARKETS FOR PETROLEUM EXPORTED FROM IRAQ, 1939

THE WIDTHS OF THE ARROWS INDICATE RELATIVE VOLUME OF PETROLEUM.

The principal products exported are crude petroleum, fuel oil, gasoline and kerosene

The petroleum of Iraq is marketed almost entirely in Europe (Fig 3). France before the war was the largest consumer, taking more than fifty per cent. of the export Since there was no refinery at the terminus of the Iraq Pipe Line at Tripoli, the oil was shipped in the crude state and was processed in France. The United Kingdom was the second largest purchaser, and the remainder went largely to the other countries of northwestern Europe. In 1939 Iraq exported the largest amount of petroleum since the beginning of exploitation. However, with the outbreak of the European War the Iraquan market was greatly restricted When France capitulated in June 1940 the British sealed the French prong of the pipe line at Haditha. During the summer of 1940 the refinery at Haifa was bombed, and transport through the Mediterranean became exceedingly hazardous As a result production had to be curtailed, and in 1941 declined to less than half that of 1939. With the defeat of the Axis forces in the Mediterranean during the summer of 1943, the Kirkuk field now supplies much of the petroleum used by the British and American fleets, and also furnishes supplies to the land forces in this region.



International Petroleum Trade, U S Department of Interior

FIG. 4. PRINCIPAL MARKETS FOR PETROLEUM EXPORTED FROM IRAN, 1939

THE WIDTHS OF THE ARROWS INDICATE RELATIVE VOLUME OF PETROLEUM.

Europe was also the largest market for the petroleum from Iran, Saudi Arabia

and Bahrein Island, but Africa and southern Asia were supplied from these fields as well (Fig 4). Europe during peace took more than half of the petroleum products. The United Kingdom was the largest consumer taking more than seventy-five per cent. of the total amount going to Europe The Union of South Africa was the second largest purchaser, and India was third The beginning of the War in 1939 likewise caused a dislocation in these markets largely excluding the European area However, this loss has been compensated by the new markets gained in the southwest Pacific since the oil fields of Burma and the East Indies have been captured by the Japanese

The capture of the Middle Eastern oil fields would give to the Axis powers a large supply of petroleum, and their defeat would be infinitely difficult Germany would no longer be dependent on the limited supplies from the Rumanian oil fields and the production of synthetic petroleum from coal The Allied forces have repelled all drives toward this region, and the fields are now no longer threatened by invasion The importance of oil has increased tremendously since World War I Navies are now entirely fueled by oil, merchant fleets largely so. Planes and tanks are numbered by thousands instead of hundreds. Thus, this region with the greatest resources of petroleum in the Old World is one of the most important areas of the war.

Petroleum in the Economy of the Middle East

The oil fields of the Middle East have been developed by foreign companies, but the right to grant concessions is vested in the national governments The concessions are granted for a long term of years for a fixed amount per acre and an established royalty on the oil production Most of the countries have also demanded a minimum royalty regardless of production or receipts. The minimum annual royalty for Iran was set at three million dollars in 1932 This was of little importance before World War II, for the annual income from royalties was more than ten million dollars However, with the loss of markets at the outbreak of war, oil revenue declined and the Iranian Government demanded a higher minimum royalty fee in 1940 The Anglo-Iranian Oil Company agreed to pay five million dollars to compensate for the loss of revenue during 1938 and 1939 and also promised to pay a minimum royalty fee of sixteen million dollars for 1940 and 1941 The greater part of the modern improvements and mechanization of the army has been made possible by means of the oil royalties Modern industry has existed in Iran for less than fifteen years The construction of cotton mills, sugar refineries and cement plants constitutes the most important industrial advancements The development of the Iranian railroad system started in the early 1930's The principal railway is the Trans-Iranian Railroad which bisects the country from north to south. In Teheran and the principal cities many of the streets have been widened and improved. A central lighting system was installed in 1936 in the capital, previous to this few facilities for electrification existed The reclaiming of land by irrigation at Khuzistan is making available some hundred thousand acres for cultivation The campaign to reduce illiteracy resulted in the opening of night schools for persons eighteen to forty years of age These schools are compulsory for illiterate policemen and government officials The foundation stones for the first Iranian university were laid in 1935

Iraq has also directed her oil royalties to the improvement of the country. When oil exploitation began on a large scale in 1932, the Iraqi Parliament de-

cided to devote the royalties to internal improvements, and a special works program was established The programs were scheduled in a series of three, four and five year capital works budgets, and the government secured a guarantee from the I.P.C. of at least a minimum of one million six hundred thousand dollars in annual royalties, in gold, to guard against price changes and quota arrangements. The oil revenue for 1939–1940 was over eight million dollars, or more than one-third of the total government receipts. One of the most important items in the program has been the reclaiming of land by irrigation. The Habbaniya Project, an example of such works, was completed in 1941. It consists of five channels from the Euphrates River near Baghdad to Lake Habbaniya. A series of regulation gates directs the overflow of the Euphrates floodwaters first into Lake Habbaniya and then onto the low-lying Abu Debbis depression to the south, where more than fifty thousand acres are being irrigated Similar works on the Mississippi River are called floodways. The railroads of Iraq have been purchased from Great Britain, and in 1939 a program was initiated for completing the line between Barji, Tel and Kotchek, the only missing railway link between Europe and Basra on the Persian Gulf. This portion of the railroad was opened to traffic in the summer of 1940. Schools are being built, and a large number of students are sent abroad each year. Other expenditures have included the construction of roads, bridges, government buildings and similar works.

Along with government expenditures, the oil companies have spent considerable sums to better the working conditions of their employees and to improve transportational facilities for the general benefit of the countries. This program has aided the modernization of the region. Petroleum exploitation in the Middle East is still in the initial period, so that with increased development of the large reserves the future of the industry is bright, and the combination of natural resources and labor with foreign capital and operating experience promises the greatest benefits to the oil countries at lowest cost and minimum risk.

THE ADVENT OF MICROSCOPES IN AMERICA

WITH NOTES ON THEIR EARLIER HISTORY

By Dr. FREDERIC T. LEWIS

PROFESSOR OF COMPARATIVE ANATOMY, HARVARD MEDICAL SCHOOL

So gradual was the invention of the microscope, through accidents and strokes of genius—so unaware were the builders of this mighty engine of its latent powers—that uncertainty prevails as to its inventor and the date of the invention. In a famous book dedicated to the Senate and People of Middelburg, Metropolis of Zeeland, *Telescopii mater Inventrix,* Dr Pierre Borel gathered affidavits to establish that Zacharias Jansen of that city was "the true inventor of the telescope "[1] "All nations have claimed it," he said, with some exaggeration. "In addition, he (Zacharias Jansen) invented the microscope as the following evidence will show" But as Zachary was a lad of about ten at that time, the evidence is inconclusive. His father, an optician in whose shop he learned the trade, presumably had a part in it; and another lens maker of Middelburg, which was noted for its glass works, applied for a patent. Borel observes "utque Deus viros miseros pro Apostolis accipere, sic etiam ex populi fæce ad hoc arcanum patefaciendum viros ignobiles eligere voluit."

In 1846, when the Elders of the Reformed Church at Middelburg sought to demolish the little house that was inhabited by Zacharias Jansen in 1590, "the government" permitted it only on condition that a stone tablet should mark the spot. It is inscribed in Dutch:—"Against this wall stood the house of Zacharias Janse, Inventor of the telescope in the year MDXC."[2]

At an unspecified date the Jansens gave the first recorded compound microscope to Prince Maurice, commander of the armed forces of the Netherlands. For that device they received some honorarium. "Much later, *viz.* in 1610," they presented him with a spy-glass, the construction of which was a military secret A second and "similar microscope" the Jansens gave to the Austrian Archduke Albert, possibly in 1605 (according to Clay and Court[3]) when he came to Zeeland. Duke Albert passed it on to Cornelis Drebbel, mathematician, engineer and inventor, who took it to England. The general appearance of that instrument has been described by Ambassador Willem Boreel, to whom it was shown by his friend, Drebbel, in London, 1619. "It magnified little particles of dust or other tiny objects to an almost miraculous degree."

Meanwhile accounts or rumors of the Dutch invention had reached Italy, and Galileo made a compound microscope on similar principles (*i e.,* with a biconcave eye-lens) in 1609. It is only by discrediting Ambassador Boreel's letter to Dr. Borel, dated July 9, 1655, as written a full half-century after the events it describes, that Professor Govi can consider Galileo to be the inventor of that form of compound microscope. Those who have given special attention to the early testimony, as Mayall finds—notably Van Swinden, Moll, Harting, and Poggendorff—are agreed that the invention must have been between 1590 and 1609;

[1] Petrus Borelius, *De vero telescopii inventore, etc.* Hagæ-Comitum, 1655. 2 l, 67 pp., 2 portr. Published with two separately paged additions, one dated 1656.

[2] A. J. van der Aa, *Biographisch Woordenboek der Nederlanden.* Vol. 9. Haarlem, 1860. pp. 95–96. The author is much indebted to Professor Taylor Starck for a translation of the entire article, "Janse (Zacharias)."

[3] Reginald S. Clay and Thomas H. Court, *The History of the Microscope.* London, 1932. pp. xiv, 266. (p. 9.)

and that among the Dutch claimants "the probabilities are slightly in favour of the Janssens "[4] But Professor Govi has truly remarked (in 1880, and again in 1888[5]) that "the glory of having reduced the *Keplerian* telescope to a microscope should rest with Drebbel. . . . The apologists of the Tuscan philosopher, by attributing to him the invention of the microscope without specifying with what microscope they were dealing, defrauded Drebbel of a merit which really belongs to him; but the defenders of Drebbel would act unjustly in depriving Galileo of a discovery which incontestably was his."

Not only did Drebbel so improve the microscope that Galileo, in 1624, on seeing his instruments, thought no more of his own *occhialino,* but it was Drebbel who introduced the compound microscope into England, and thus indirectly to America. "He did a great deal to make this instrument generally known all over Western and Southern Europe."

Drebbel was described as a handsome man, of gentle manners, though badly dressed and looking like a Dutch farmer "I do not remember," said the painter Rubens, "ever to have seen a man of more extraordinary personal appearance than he." So one looks attentively at the little portrait on the title page of his "Short treatise on the nature of the elements" (in the Haarlem, 1621, ed.) reproduced by Dr. Tierie in his fascinating and well-documented biography.[6] In outline Drebbel's career, as presented by Dr. Tierie, is as follows.

Cornelis Drebbel (1572–1633) was born in Alkmaar in North Holland, and spent the first half of his life in his native land. Without formal education, he became a professional engraver, associated with the expert Hendrik Goltzius, whose sister he married in 1595. As an inventor he early took out patents for a pump, a time-piece and a chimney. In 1601 he was at Middelburg, constructing a fountain for the municipality. There he may have learned to make glass and grind lenses, of which arts he was later a master. In 1604 he published a small book *On the Nature of the Elements, and how they bring about wind, rain, lightning, thunder and why they are useful* It was translated into several languages and there were many editions. Shortly thereafter he moved to Eltham, a suburb of London, where he set up a perpetual motion device—a sort of air thermometer, rising and falling with the daily temperature rhythm. All England knew of it Among other references, Dr. Tierie cites Ben Jonson's *Silent Woman* (1609, Act V. Sc. 3), where the distraught husband exclaims,—"My House turns round with the Tumult . . . The Perpetual Motion is here, not at Eltham!"

Drebbel entertained King James I with his inventions, which included a self-playing clavichord; and he was appointed tutor of the Prince of Wales. Rudolf II, Emperor of Germany, invited him to Prague, where he spent three years (1610–1613). There he made gold alloys for the German mint, and demonstrated his "*Perpetuum mobile.*" Gali-

[4] John Mayall, Jr, "The Microscope " Cantor lecture 1 *Jour Soc. of Arts,* 1886, vol. 34, pp 987–997 (p 992) Also Alfred N Disney, *Origin and Development of the Microscope. An Historical Survey.* London, 1928 pp xii, 303. (The evidence is reviewed at length, pp 89–108) Also Charles Singer, "Notes on the Early History of Microscopy," *Proc Roy. Soc. of Med* , 1914, vol. 7, Sect. on Hist. of Med , pp. 247–279. (p 256. "Zacharias, miscalled Jansen," since there was no family name.)

[5] Gilberto Govi, "Nuovo documento relativo alla invenzione dei Cannocchiali Binocoli " *Bull. d. Bibliografia e d. Storia d. Sci. Mat. e Fis.,* 1880, vol 13, pp. 471–480. Also· "Il microscopio composto inventato da Galileo " *Atti R. Acad. Sci Fis e Mat , Napoli,* 1888, ser. 2, vol. 2. A complete anonymous translation of the latter, "The Compound Microscope Invented by Galileo," is found in *Jour. Roy. Micr. Soc.,* 1889, Pt 2, pp. 574–598.

[6] G. Tierie, *Cornelis Drebbel (1572–1633).* Amsterdam, 1932 pp. viii, 124. The writer has quoted this admirable biography *ad libitum.*

leo was informed of it by Ambassador Guglio de Medici; and in 1612 Antonini sent him, from Brussels, a full description of the device.

When Drebbel returned to England, he had been given, as already noted, the Jansen microscope which he demonstrated to Boreel in 1619. In 1620 he visited Zacharias Jansen in Middelburg, no doubt discussing the production of microscopes and telescopes. A year later there were to be seen, at his house in London, microscopes of the new pattern, with the biconvex eye-lens. Constantyn Huygens, of the Dutch legation, father of the famous physicist, Christiaan Huygens, wrote in his autobiography,—"Even if he should prove to have achieved nothing else in his whole life, this wonderful glass gives him a right to an immortal name." In 1629 Rubens said in a letter,—"They assure me, in sooth, that for many years he has made nothing but that optical instrument, the tube of which stands up straight, and that objects placed under this are exceedingly much enlarged."

About 1620, two young Dutchmen living in Germany—Abraham Kuffler and his younger brother Jacob—"having only very slender means of subsistence" came to England, hoping to be rewarded by King James for a book they had written. "But the King did not trouble himself in the least about the book." Then they visited Drebbel, and realizing the advantages to be enjoyed could they but gain his favor, they both decided to try to win the hand of his daughter. "He whom she should love most should marry her." Thus Dr Tierie translates de Peiresc's instructive letter. "The plan succeeded; the girl preferred the one who was not learned (this was Abraham) because he was handsomer in appearance; he proposed to her and married her, he and his brother helping Drebbel with all possible zeal and energy."

"In the spring of 1622 (before the wedding had occurred) Drebbel sent Jacob Kuffler to demonstrate and sell the new microscopes on the Continent. On May 22 Jacob gave a demonstration in Paris in the apartments of Maria de Medici, the Queen-Mother, who was much interested in optical instruments. De Peiresc[7] was present, and was immediately seized with great enthusiasm for the new invention."

Within a fortnight de Peiresc had obtained one of the microscopes for himself, and his manuscript description of it is regarded by Dr. Tierie, who quotes it in full, both in the original French and in English translation, as "the first complete and very accurate description of a microscope that we possess." De Peiresc gave Jacob Kuffler letters of introduction to his brother in Aix, and to others in Rome, who might obtain for him audience with the Grand Duke of Tuscany and with Cardinals di Santa Susanna and Barberini (later Pope Urban VIII). King James, Prince Maurice, and the Duke of Anjou (brother of the King of France) had already been provided with the Drebbel microscopes. But poor Kuffler died of the plague in Rome before he could show "the marvellous effects of his *occhiale*." How de Peiresc succeeded in transmitting a microscope to Cardinal di Santa Susanna in 1623 is told by Professor Govi. They had trouble in setting it up, but in May of 1624, Galileo chanced to visit Rome and

[7] Nicolas Claude Fabri de Peiresc (1580–1637), Senator of Aix, wealthy man of letters and patron of science, prepared "un grand nombre de traités sur toutes sortes de sujets." He studied the development of the chick with Fabricius, and demonstrated human lacteals by having a condemned criminal well fed before hanging and promptly brought to the Anatomick Theatre (1634). Gassendi published his *Vita*, 1655; Englished by W. Rand, 1657. His obsequies were issued in Carmina in 40 languages entitled *Panglossia* (Rome, 1638). "The prodigious *Learning*, wherewith some great Literators have been enriched!" is Cotton Mather's comment thereon.

showed them how to manipulate it. De Peiresc was pleased that Signor Galileo understood it; though even so, they did not obtain "as clear an effect as it gives in its proper adjustment."

With Drebbel's later history we are hardly concerned. He had developed a submarine, open below, in which "he calmly dived under the water, while he kept the king and several thousand Londoners in the greatest suspense—for three hours as rumour has it." It carried 24 people, could travel a few miles, and was provided with air freshened, apparently, with oxygen derived from saltpetre. The depth was determined by a mercury barometer. Since "it is not hard to imagine what would be the usefulness of this bold invention in time of war" (as Huygens wrote in 1631), Drebbel — a non-resistant anabaptist — was employed by the British Admiralty, for whom he made floating mines to set fire to the French fleet. Before La Rochelle, one of them took effect, throwing water into the ship "with much power; all the others were captured as they floated on the water and did no harm." "Some laughed at King James, saying that this everlasting inventor has never achieved anything the cost of which has been covered by its usefulness," and late in 1628 Drebbel was dismissed from the service.

"He was very poore, and in his later time kept an Ale-house below the [London] bridge." Two other Kuffler brothers had come to England, one of whom, Dr. John Sibertus Kuffler (M. D., Padua, 1618; "Physician to the Duke of York") married Drebbel's second daughter, Catherina. After Drebbel's death, in Trinity Parish, London, 1633, Dr. and Mrs. Kuffler sought to perpetuate and develop his discoveries. There were devices for the army and navy, thermostatic incubators, a camera obscura of service to artists, and the tin-mordanted cochineal—"the lovely colour"—known all over Europe as the finest scarlet dye. "The Drebbel microscopes were now well known and were being made in Holland, England, France and Italy."[8] Hooke's microscopes, it is said, were developed from the Drebbel pattern. As a "deservedly famous Chymist" Drebbel was known to Boyle—Pepys, Evelyn, Digby and Wren also have referred to him—and his influence extended to America.

John Winthrop, Jr. (1606–1676), the first American colonist to be elected to the Royal Society, had among his books a small duodecimo containing two works by Basil Valentine,—*Von den naturlichen und obernaturlichen Dingen*, 1624, and *De occulta philosophia*, 1603. On the fly leaf, penned and signed by Winthrop, is the note,—"This was once the booke of that famous philosopher and naturalist, Cornel Drebbel, who usually carried it with him in his pockett and after his death was given me by his sonne-in-law, Mr. Abram Keffler."[9]

Among the Winthrop papers is a letter from Abraham Kuffler, dated London, June 12, 1639, in which he admits that,

> . . . sseeing all Christendome in armes, and all kings and princes tacken that waye, I was forst to leaffe off all curious inventissions. I now onely follow dieing of scarrlett, in which I have so much to doe that I can follow nothing elles. . . .[10]

Two letters from Dr. John Kuffler, in 1660 and 1662 respectively, continue the friendly correspondence, perhaps hoping for financial aid from Winthrop's "rich mine" in Connecticut.

Between 1661 and 1663 John Winthrop was in England, primarily to obtain a charter for Connecticut, and by his winning personality and influential friends he secured "the most liberal

[8] Clay and Court, *loc. cit*, p. 12.

[9] C A. Browne, "Scientific Notes from the Books and Letters of John Winthrop, Jr." *Isis*, 1928, vol. 11. pp. 325–342. (p. 329.)

[10] *The Winthrop Papers*, Part 3. Coll. Mass. Hist. Soc, 5th Ser., vol. 1, 1871. (pp. 270–271.)

charter that had yet been granted to any colony." He was elected Fellow of the Royal Society in 1663, and came home with a telescope, with which, on August 6th, 1664, he thought he observed a fifth satellite of Jupiter.[11] There was a general interest in astronomy in the colony, and when, in 1672, he gave a telescope to Harvard it was enthusiastically acknowledged. Although Winthrop had abundant opportunity to hear of microscopes and to obtain one, there is no record that he did so. In 1663, the year of Winthrop's election to the Royal Society, Monsieur Monconys, of Lyons, came to London. He was traveling everywhere in search of novelties in apparatus, and curiosities in chemistry.[12] Already he had a compound microscope with four lenses, of which he has given a diagram and full specifications. He visited Dr. Kuffler, who "works at chemistry all the time, but in which he has found nothing new." Monconys bought some lenses of a maker opposite the Exchange, but not the best, as Sir Kenelm Digby told him, recommending one named Bailey, at St Paul's cemetery "He directed me also to Mr Reeves of Long Acre, who makes excellent microscopes." Soon afterwards, Monconys visited Boyle with whom he talked physics chiefly, but he noted that Boyle had a very good telescope, and two excellent microscopes, "qui surpassoient en grosseur les miens, mais non pas en clarté." Boyle, he said, examined the texture of ox eyes by freezing them, naturally in winter, artificially in summer, after which he cut them easily with a penknife. At Sir Christopher Wren's house he saw that famous architect's original draughts of insect parts, made with the microscope, which well nigh discouraged Robert Hooke from proceeding with his own *Micrographia*. In short, London teemed with microscopy when John Winthrop returned to Connecticut. He might have brought the microscope of which we first hear twenty-two years later, in the Mather family, which was on very friendly terms with the Winthrops, but that is a remote possibility. Cotton Mather (1663–1728) who was born in Boston, and who never traveled "farther, perhaps, than New Haven,"[13] has very indirectly made known that he owned and used a microscope in 1685. Where it came from and what sort it was, he has never specified; and yet these are matters of some interest in view of the *possibility* that it was the first in America.[14]

"Cotton Mather, the New England Puritan divine, is generally considered a rather grotesque pedant," writes William James in his *Varieties of Religious Experience*, "yet what is more touchingly simple than his relation of what happened when his wife came to die?"[15] "A typical infant prodigy grown up,"

[11] Frederick E Brasch, "The Royal Society of London and Its Influence upon Scientific Thought in the American Colonies." *Scientific Monthly*, 1931, vol. 33, pp. 336–355, 448–469. (pp. 341–2)

[12] Balthasar Monconys (1611–1665), *Journal des Voyages . . . Où les Savants trouveront un nombre infini de nouveautez*, etc. En trois parties. Lyon, 1665 et 1666. (His own microscope is described in Part 1, pp. 122–128 (see also Disney, *loc. cit.*, p. 109): his visit to England, Part 2, pp. 11, 40, 45 *et al.*)

[13] Thomas J. Holmes, "Cotton Mather and His Writings on Witchcraft " Papers of the Bibliographical Soc. of America, 1926, vol. 18, pts 1 and 2. 29 pp

[14] The New York Academy of Medicine has a microscope on the case of which is a brass plate inscribed "This Microscope brought from Holland by Jan Evertson Keteltas in the year 1649 is given by his Descendent Henry Keteltas, Aug. 12th 1895 to Doctor Warren Coleman as a pleasant remembrance " The case belongs with, and contains, a Culpeper tripod microscope, made by Benj. Cole of London, who began independent business in 1751. (See Bull. N. Y. Acad. Med. 1930, vol 6, pp 740–742). Nevertheless the unverified report was given wide circulation (*Jour. Am. Med. Asn*, 1930, vol. 95, p. 1921 *Science*, 1931, vol 73, p. 10). When microscopes were first brought to New York is apparently still an open and an interesting question.

[15] William James, *The Varieties of Religious Experience*. London, 1902, pp. xii, 534. (p. 303, where the passage from Mather is quoted.)

is Morison's later judgment, "pedantic and conceited, meddlesome and tactless."[16] Worst of all, he is held accountable for the score of Salem witchcraft executions. "No one was more active in fighting the Devil's works as revealed in witchcraft: no one for well on to two centuries, has borne so much of the odium of what was done as he."[17] Yet the first hanging for witchcraft in Boston occurred nearly fifteen years before he was born. The Court sought to obey the command: *Maleficos non patieris vivere* (Thou shalt not suffer a witch to live: Exodus 22.18).

The guilt was not all Mather's, nor in that parallel tragedy was Calvin solely responsible for the burning of Servetus. Where the stake once stood, "duteous and grateful followers of Calvin, our great reformer" have erected an expiatory monument "condamnant une erreur qui fut cela de son siècle" "Give the devil his due, John Calvin was a great man," said Bishop Berkeley.[18] For Cotton Mather, also, such is the only line of defence.

Mather published too much, and said so. "A Great Fault . . I *do* confess, That I have written too many Books, for one of my small Attainments" (*Winter-Meditations*, 1693) No less than 437 published works, exclusive of reprints, prefaces, and unprinted manuscripts, have been counted. "Be Brief" was the placard which Franklin saw in Mather's study, when he called there in 1724, and received other useful counsel. Two of Mather's early publications are in verse. We are not concerned with his "Poem" in memory of President Oakes of Harvard College, Boston, 1682, but only with "An Elegy on the much-to-be-deplored death of that never-to-be-forgotten person, the Rev. Mr. Nathanael Collins," Boston, 1685. The Rev. Mr Collins (A.B., Harv. 1660) was the first minister of a church in Middletown, Conn, with a meeting-house 20 feet square, 10 feet from sill to plate, and enclosed in palisades against the Indians. The Elegy includes the following stanza and footnote:—[19]

I would that you, my Friend, each *drop* of Ink
  Could fill with *Elogyes* no fewer then
The little *eels** that may swim in't I think
  They all should celebrate this *Flow'r of men.*

* *of which I can with my* Microscope *see incredible hundreds playing about in one drop of water*

Can a punning consonance of eel and elegy have been intended? (Certainly so, if O. W. Holmes had written it!) But the microscopist is not familiar with myriads of eels in a drop of *water* The incredible hundreds of eel-like forms occur in a different fluid, as Leeuwenhoek had made known to the Royal Society; and Mather, who read everything, was surely aware of it For reasons which led Hoole to omit all reference to spermatozoa in his voluminous *Select Works of Leeuwenhoek* (London, 1800), Mather may have preferred to refer to the denser fluid as water. In his *Christian Philosopher* (London, 1721, p 151) Mather states that "Mr. *Derham*, in a *Drop* of the *green Scum* upon Water, a *Drop* no bigger than a Pin's-head, sees no fewer than an hundred [little Insects] frisking about. How vastly many more in a *Drop* of *Pepper-water!* How vastly many, many, many more, in a Drop of the *Leuenhoe-*

16 Samuel Eliot Morison, *Harvard College in the Seventeenth Century.* Cambridge, 1936. Part 1, pp xxii, 360; Pt. 2, pp. xviii, 361–707. (p. 503)

17 Barrett Wendell, *Cotton Mather, the Puritan Priest* New York (no date) reprint, Cambridge, 1926, pp. viii, 321. (p. 100.)

18 Noah Porter, *The 200th Birthday of Bishop George Berkeley.* New York, 1885. pp vii, 84. (p 44)

19 Reprinted in The Club of Odd Volumes. III. Early American Poetry. A Poem and an Elegy. By Cotton Mather Boston, 1896 With an instructive preface by James F. Hunnewell. The writer is greatly indebted to Mr Frederick G. Kilgour for discovering for him this important reference to the microscope (p. 5 of the Elegy) and for other valued notes

kian Examination!" This circumlocution tallies with the Puritan's recognition that the sexual stimulus is sufficient without aphrodisiacs; its superabundant appeal should be quieted through modesty in dress, decency in books and drama, and much else derided as puritanical. "There should be in our Praises an Amputation of all that is improper."

The preceding quotation is from "The Wonderful Works of God Commemorated: a Thanksgiving Sermon" by Cotton Mather, delivered in Boston, Dec 19, 1689, and published in 1690 In that also, Mather refers to his personal observation with the microscope

> And the *Little* things which our Naked Eyes cannot penetrate into, have in them a *Greatness* not to be seen without Astonishment By the Assistance of *Microscopes* have I seen Animals of which many Hundreds would not Æqual a Grain of Sand How Exquisite, How stupendous must the Structure of them be! The Whales . . . methinks . . . are not such Wonders, as these minute Fishes are [20]

Cotton Mather was always deeply interested in medicine In his Diary he records the birth and death of his first son as follows:[21]

> On March 28 [1693] Tuesday, between 4 and 5 A. M God gave to my Wife, a safe Deliverance of a *Son* It was a child of a most *comely* and *hearty* Look . . . But the Child was attended with a very strange Disaster, for it had such an obstruction in the Bowels as utterly hindred the passage of its Ordure from it Wee used all the Methods that could be devised for its Ease, but nothing wee did could save the Child from Death It languished, in its Agonies, till Saturday, April 1 about 10 h P. M and so dy'd, *unbaptised* . . I did not suffer such a Discomposure in my Thoughts, as to hinder mee, from preaching both parts of the Day following . . On the Monday, the Child was buried, with a very numerous and honourable Attendance of my Neighbours, and on one of the Grave stones, I wrote only that Epitaph, Reserved for a Glorious Resurrection
>
> When the Body of the Child was opened, wee found that the lower End of the *Rectum Intestinum*, instead of being *Musculous* as it should have been, was *Membranous*, and altogether closed up I had great reason to suspect a *Witchcraft* in this praeternatural Accident, . . . However, I laid little *Stress* on this Conjecture.

Later in 1693, Mather published his *Winter-Meditations*, in which there is a brief passage quite similar to that already cited from his "Thanksgiving Sermon" But instead of asserting "have I seen," the reference is merely to what "our microscopes" reveal "As for our Bodies," he reflects, "What a sad thing it would have been, if these had been monstrously *Deformed*, or *Defective* in any One of all their *Members*. Truly, There are Thousands of *Mercies* and *Wonders*, in one *perfect* Child!"

Meanwhile (in 1692) Cotton Mather's father, the Rev Increase Mather, President of Harvard, had returned from England bringing a new telescope for the College. He had spent many hours with Robert Boyle, and visited John Flamsteed, Astronomer Royal, to view the stars,[22] but there is no record of any microscope purchased, or of any collegiate interest in microscopy. Thus Cotton Mather's book of 1721, *The Christian Philosopher*, becomes the more notable. Its first half, indeed, is devoted to astronomy and the inorganic world; but in the final 72 pages there is a résumé of gross and microscopic observation of animals and plants, astonishing in scope and penetration Everyone seems cited, —Grew, Malpighi, Leeuwenhoek, Cesi as discoverer of "seeds" in ferns, Kircher as to vermiculated blood, Bellini on the tubes and siphons of the kidney, Dr. Mead observing with the microscope a parcel of small salts in the poison of the viper "We will not meddle with the Controversy between *Etmuller* and *Wil-*

[20] This passage has been cited by Theodore Hornberger, in "The date, source, and the significance of Cotton Mather's interest in Science" *American Literature*, 1934, vol 6, pp 413–420.

[21] "Diary of Cotton Mather," 1681–1708. Coll. Mass. Hist Soc, 1911, 7th Ser, vol. 7, pp. 1–604 (p. 163.)

[22] Kenneth Ballard Murdock, *Increase Mather, the Foremost American Puritan.* Cambridge, 1925, pp. xv, 442. (pp. 264–5.)

lis, whether the *Vesiculæ* of the *Lungs* have any muscular Fibres, or no."

There is indeed great dependence on his library—which was a large one, he thanked the Lord (ultimately nearly 4,000 volumes)—rather than on direct observation. Yet, according to Zirkle, the *Christian Philosopher* contains the earliest published account of plant hybridization yet found.[23] Another personal observation concerns the passenger pigeon, now extinct:—"One Man has at one time surprized no less than *two hundred dozen* in his Barn, into which they have come for Food, and by shutting the door, he has had them all." Anticipating John Hunter,[24] he continues (p. 192):

> The *Cocks* take care of the *young* ones for one part of the day. . . . In the Crops of the *Cocks*, we find about the quantity of half a Gill of a Substance like a tender *Cheese*-Curd. the *Hens* have it not This *Curd* flows naturally into their *Crops*, as *Milk* does into the *Dugs* of other Creatures. The *Hens* could not keep their *young* ones alive when first hatched; but the *Cocks* do fetch up this *thickned Milk*, and throw it into the Bills of their *young* ones, which are so nourished with it, that they grow faster, and fly sooner than any other Bird among us. None but the *Cocks* which have young ones to care for, have this *Curd* found in their *Crops*

The crowning service of Cotton Mather came in 1721, in combating an epidemic of smallpox. That story is a familiar one. With his father's approval, he advocated inoculation and called a conference of physicians. "Only one, Dr. Zabdiel Boylston, had the courage to make the trial." On June 26, Boylston inoculated his 6-year old son Thomas, and two of his negro slaves, a grown man and a boy, all successfully. Though the town was horrified, the practice spread, defended by the Mathers as the means "for the saving of many a life."[25]

The microscope reached Canada (if our information suffices) by a very different route, sponsored by the Académie des Sciences de Paris instead of the Royal Society of London. Michel Sarrazin (1659–1735), who was born at Nuit-sous-Beaume, Burgundy, arrived in Quebec in 1685, accompanying a detachment of marines as surgeon.[26] He was at once a busy and successful practitioner. In fact, hospital appointments, accidents, duels, and the siege of Quebec furnished him an "assez vaste pratique." Then, after a severe illness in 1692, he thought of entering the priesthood—his brother was a priest—but, as the Abbot Tremblay regretfully found, the surgeon had not yet acquired "cette latitude de coeur qui nous fait reposer amoureusement en l'aimable providence de Dieu." Instead, Sarrazin returned to France, in 1694, for three years of study in *medicine*. They were spent in Paris, where the active Academy and the flourishing Jardin des Plantes awakened in him new interests. But he went on to Reims to receive the doctor's degree in medicine, returning to Quebec in 1697 at the urgent call of his clientèle.

In 1699 Sarrazin became "corresponding member" of the French Academy,

23 Conway Zirkle, "More Records of Plant Hybridization before Koelreuter." *Jour. of Heredity*, 1934, vol 25, pp. 1–18. (Wherein Mather's letter of 1716 is published for the first time; yet the changes in the *Christian Philosopher* version of 1721—"my two mites . . . a couple of experiments." (pp. 124–5)—are but slight)

24 John Hunter, *Observations on Certain Parts of the Animal Œconomy.* London, 1786 "On a Secretion in the Crop of Breeding Pigeons, for the Nourishment of Their Young." (pp. 191–197, 2 pls)

25 "*Several Reasons Proving that Inoculating or Transplanting the Small Pox is a Lawful Practice. . . .*" *By Increase Mather.* "*Sentiments on the Small Pox Inoculated.*" *By Cotton Mather* Reprinted from the original folio single sheet printed at Boston in 1721. With an Introduction by George Lyman Kittredge. Cleveland, 1921.

26 Arthur Vallée, *Michel Sarrasin, sa vie, ses travaux, et son temps.* Quebec, 1927. p. viii, 291, including an important appendix of letters and documents This "brilliant study" has been freely used by the writer: it is reviewed at length by Dr. Maude E. Abbott, *Canadian Med. Assoc. Jour.*, 1928, vol. 19, pp. 600–607.

and the distinguished botanist, Pitton de Tournefort, was assigned to receive his first communications. In 1700 the king at Versailles, in recognition of his experience and ability, appointed him "Médicin des hôpitaux de la Nouvelle-France." In that year Sarrazin sent to Tournefort a description of the anatomy of the beaver, in which he states, —"Si on considere ce poil [the coarser hair] avec un Microscope, on remarque dans son milieu une ligne beaucoup moins opaque que les côtez, ce qui fait conjecturer qu'il est creux."[27] There is no further reference to the microscope in that paper; and the stomach, which was rather carefully examined, is said to have no glands, although the lining of certain localized vesicles "paroît glanduleux." The publication of American observations in the field of microscopic anatomy may have begun with that note of Sarrazin's on the apparently hollow hairs of the beaver.

In 1702, as recorded in the Annales de l'Hôtel-Dieu, smallpox, brought by an Indian, spread like wildfire through Quebec, sparing not a house. Mortality was such that the priests could not bury the dead, nor attend the dying. Without ceremony bodies were brought daily to the cathedral, and in the evening were buried—sometimes 15 or 18 together. That lasted several months, so that the deaths in Quebec exceeded two thousand. Since fewer died in the hospital than in the town, it was filled to capacity.

[27] "Lettre de M. Sarrasin touchant l'anatomie du Castor." *Histoire de l'Acad roy. des Sci*, Paris, Année 1704, pp 48–66. (p 48) Sarrazin's "microscope" was a poor lens (see below), held in the hand toward a sun-illumined object, and Vallée suggests that he had "apparently borrowed it from the Jesuits." Christophorus Scheiner, S.J. (1575–1650) made a Keplerian microscope prior to 1626 (cf S H Gage, *The Microscope*, 17th ed. 1941, p. 561), and Father Kircher, S J. (1602–1680) was a renowned microscopist Could their influence and example have extended to America?

Dr. Sarrazin's next paper was delayed. It dealt with the muskrat, called by the Indians the younger brother of the beaver. It was a serviceable study,[28] illustrated by the author, but contained nothing microscopic. In fact Sarrazin was embarrassed by his inability to find any connection between the epididymis and testis, which were rather widely separated. Réaumur, who was Sarrazin's correspondent after the death of Tournefort, told him that Winslow questioned his observations. Others challenged the statement in his third paper (on the porcupine)[29] that the quills seen "au Microscope" had a screw-like filamentous tip, just below which they were retrorsally barbed "You astonish me, Sir," wrote Sarrazin in reply, "for you are equipped with all the necessary means for easily settling the matter, whereas I have only a lens which is not a good one. Poor as I am, I can scarcely obtain the instruments needed to reveal structures that can not be seen." So the Academy sent him "une loupe qui grossise considérablement" and one of the best injection-syringes obtainable, which he acknowledged in a letter of Oct. 10, 1727. At the same time Sarrazin said that he had decided not to dissect a skunk, because of the poisonous stench. As to the penetrability of the porcupine quills he informed the Academy that a hunter, named d'Orval, shot a young bear that had met a porcupine. Carrying the bear on his shoulders, as a shepherd does a sheep, a porcupine quill entered the back of his neck. After five years of debility, the hunter found the quill emerging from the front of his body On extraction there was immediate improvement, and an ultimate return to perfect health. Some quills, Sar-

[28] "Extrait de divers memoires de M. Sarrazin sur le rat musqué." *Hist. de l'Acad.*, Paris, Année 1725. pp. 323–345. Pls. 11–14.

[29] "Observations sur le porc-épic." *Hist. de l'Acad.*, Paris, Année 1727. pp. 383–395.

razin observed, lacked the barbs and perforatorium, being perhaps only partly developed. His final description of the tips seems to be that they are rough "like a rasp or rat-tail file."

Since no distinction is made between "loupe" and "microscope" in Sarrazin's researches, and the instrument is not described, it may have been a simple lens which the Académie sent him in 1727, or a more elaborate apparatus In the hospital wards in 1734, the doctor contracted a malignant fever, of which he died two days later. His monument is the genus *Sarracenia,* based upon one of the many Canadian plants that he sent for cultivation to the Royal Garden in Paris.

In 1732, Harvard College received from Thomas Hollis, of London, the gift of a Wilson "screw-barrel" microscope, with a hint that it was time for the college to use it [30] It was presumably a simple microscope, with a second lens as a condenser. Little was done with it, however. It was available in the undergraduate years of Edward Bromfield (1723/4–1746) of the class of '42, who became more interested in such apparatus than his distinguished professor, the mathematician and astronomer, John Winthrop, F.R.S (1714–1779). For on graduation, Bromfield, with Newton's *Opticks* and Hooke's *Micrographia* as guides, apparently both bought and made microscopes, "most accurately grinding the finest glasses." That he made and used them successfully is known by the merest chance. His pastor, Dr. Thomas Prince, saw him demonstrate a solar microscope at the Bromfield home in April, 1744, and was so impressed that he took notes, and published details of the display in his obituary notice of the young inventor [31] For Bromfield died at the early age of twenty-two. The story is briefly told in the *Memorial History of Boston,* where the Greenwood painting of Bromfield, pointing with pride to a microscope of the Culpeper type, has been reproduced.[32]

Adjoining the Bromfield estate on the top of Beacon Hill was the Bowdoin mansion, and James Bowdoin (1726–1790) the future governor, and the first president of the American Academy,[33] must have known what his neighbor Edward, of about his own age, was doing with his microscopes. Bowdoin became interested in the phosphorescence of sea-water dashed by the oars. In a letter to Benjamin Franklin,[34] Nov. 12, 1753, he rejected the idea that it was due to particles of putrid fish and suggested that "the said appearance might be caused by a great number of little animals, floating on the surface of the sea, which, on being disturbed, might, by expanding their fins, or otherwise moving themselves, expose such a part of their bodies as exhibits a luminous appearance, somewhat in the manner of a glow-worm or fire-fly. . . .

[30] Frederic T. Lewis, "The Hollises and Harvard" *Harv. Grad Mag*, 1933, pp. 107–120. (pp. 109–110)

[31] Thomas Prince, "Letter to the Publisher." *Amer. Mag and Hist. Chron*, Nov. 30, 1746, vol. 3, pp. 548–551

[32] Justin Winsor, editor *The Memorial History of Boston* Boston, 1880–81 Notice of Edward Bromfield, vol 4, pp 509–510, portrait, p. 509 The original painting, formerly attributed to Smibert, is now in the corridor of the Department of Anatomy, Harvard Medical School, as part of a collection of mementos of Harvard microscopists, gathered by the writer over a number of years. Utilizing this exhibit without acknowledgment or perfect accuracy, Dr. B. Earl Clarke, in his paper "The History of the Microscope" (*R I. Med. Jour*, 1942, vol. 25, pp. 131–139) states that Cotton Mather "tells about seeing animalcules in ink" (!) and that Holmes passed around his demonstration microscopes "within a box" (!). The meager Bromfield records and papers are all on display. Unfortunately not any of his microscopes have been preserved

[33] See Brasch, *loc. cit.* (in footnote 11), pp. 461–3.

[34] Jared Sparks, editor *The Works of Benjamin Franklin.* Vol. 6, Boston, 1838. pp. 190–192 Bowdoin's letter "Concerning the Light in Sea-Water" was read at the Royal Society, Dec 6, 1756. Franklin's reply is in vol. 5 of the *Works,* 1837, pp. 337–339.

There is no difficulty in conceiving that the sea may be stocked with animalcula for this purpose, as we find all nature crowded with life." (Although Harvard College received from him "a valuable microscope" in 1758, Bowdoin has been altogether reticent about having used one in this or other connections)

Dr. Franklin replied on Dec 13, 1753:

The observation you made of the sea water emitting more and less light, in different tracts passed through by your boat is new, and your manner of accounting for it ingenious. It is indeed very possible, that an extremely small animalcule, too small to be visible even by the best glasses, may yet give a visible light I remember to have taken notice, in a drop of kennel water, magnified by the solar microscope to the bigness of a cart wheel, there were numbers of visible animalcules of various sizes swimming about; but I was sure there were likewise some which I could not see, even with that magnifier; for the wake they made in swimming to and fro was very visible, though the body that made it was not so

Microscopes had at last become common in America. The foregoing notes, derived from a very incomplete examination of records locally available, are subject to revision—perhaps radical revision The story of the coming of the microscope to other cities and colleges than those mentioned, is admittedly of equal or greater interest. When all the data have been gathered, some future writer may supply a forgotten page in American history [35]

[35] Since the preceding paper was submitted for publication (September, 1942) Prof. Lorande L Woodruff has described "The Advent of the Microscope at Yale College," *American Scientist*, July, 1943, vol. 31, pp 241–245 He finds that "there was but one microscope at Yale until 1789," but that one was a Culpeper, purchased for the Trustees on May 19, 1734, of the London optician, Mr Scarlet (perhaps "that excellent workman, Mr. Scarlet, *jun.*"—see *Phil Trans*, 1736, vol. 39, p 260) This relic is "still in usable condition," and appears to be the first *compound* microscope definitely known to have been acquired in America

GROWTH AND CHARACTERISTICS OF INDIA'S POPULATION

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NEW YORK, N. Y.

EVERY day India adds to her population the equivalent of a town of almost fourteen thousand inhabitants. This means that India's population increases every year by at least five millions. According to the census taken on March 1, 1941, India's population was 388,800,000. Today it must have reached the mark of four hundred millions At this rate, according to some calculations, India may reach the staggering figure of seven hundred millions by 2001 A.D. But we need not be so imaginative as that, for sufficient unto the day is the population thereof.

This seemingly rapid growth of India's population is in sharp contrast to the growth of population in some countries of the European and American continents, where the population either has been growing slowly or is stationary or showing a tendency to decline. For instance, the situation in the United States of America is in sharp contrast to the tendency in India. "If the birth rate of the United States should continue to decline as it has during most of the present century by about the year 1975 (just twenty-five years hence) there would be no babies born at all."[1] But we need not be so unduly pessimistic, for the present torrent of babies seems to be well-nigh a war boom and conditions such as this may be expected to take care of the dismal prospect of no babies being born at all at some future date And nobody need worry that this nadir in the birth rate of the United States or any other country, and much less India, will be reached.

[1] H. P. Fairchild, *People* p. 1.

GROWTH OF POPULATION

Let us look into the growth of India's population from the times when only rough estimates were possible down to recent decades when a fairly reliable census count has been made possible. In the sixteenth century, India's population, according to some rough estimates, was nearly 100 millions. In the middle of the nineteenth century, the figure reached about 150 millions In 1881, when the first regular, though incomplete, census was taken, the population stood at 254 millions. In 1931, fifty years later, the population was 353 millions, according to the census report, which represented, incidentally, an increase of 10 6 per cent. over the figure of 1921. The figure of the eighth decennial census of 1941 was 389 millions, which is an increase of 50 millions, or 15 per cent, over the 1931 census figure.

Ever since the first official census was taken in 1871, India's population has been growing from decade to decade for several reasons Since the formation of what was called the Indian Empire as a part of the British Empire and after 1931, the population of India included, besides the geographical India, Burma, which was a province of India, and even Aden, which was classed as a part of the Indian Empire, but excluded the island of Ceylon, the British Crown Colony, immediately southeast of India. However, the Government of India Act of 1935, which came into force in April, 1937, effected the political separation of Burma and Aden from India proper and today's population figure is for geographical India alone. The accom-

GROWTH OF INDIA'S POPULATION IN MILLIONS

Year	Source	Population	Increase due to: Change in area	Increase due to: Better methods	Real increase	Increase in %
1600	Moreland's estimate[2]	100				
1750	Shirras's estimate[3]	130				
1847	McCulloch's estimate[4]	133				
1850	Mukerjee's estimate[5]	150				
1861	Our estimate	164				
1872	1st partial census[6]	206.2				
1881	Regular and rather complete census[7]	253.9	33	12	3	1.5
1891	3rd and complete decennial census[8]	287.3	6	3	24	9.6
1901	Census[9]	294 3	3		4	1 4
1911	Census[10]	315 2	2		19	6.4
1921	Census[11]	318 9			4	1 2
1931	Census[12]	352 9[14]			34	10.6
1941	Census[13]	388 8	−14 (Separation of Burma)		50	15 0

[2] Moreland, W. H. *India at the Death of Akbor* (1927).
[3] Shirras, F. G. *Poverty and Kindred Economic Problems of India* (1931).
[4] McCulloch *Descriptive and Statistical Accounts of the British Empire* (1847).
[5] Mukerjee, R. *Food Planning for 400 Millions* (1938) p. 3
[6–13] Census Reports of the Government of India.
[14] Up till 1931, the census figures, as already observed, indicate population for both India and Burma. In 1931, the population of India alone was 338 1 millions and the population figure for 1941 is for India alone.

panying table summarizes the growth of India's population from the sixteenth century down to the last eight census decades and presents the percentage of increase for the same period.

The figures of population and the ratio of growth from the above table are summarized below for the regular census years for India proper.

Census year	Population 000 omitted	Increase: Net	Increase: Percentage
1881	250,125		
1891	279,548	22,471	9.0
1901	283,827	4,278	1 5
1911	302,995	19,169	6 8
1921	305,674	2,679	0.9
1931	338,119	32,445	10.6
1941	388,800	50,681	15.0

So India's population today must be about 400 millions—the largest population of any country in the world that has a regular official and periodical census count Some students of Indian demography have been more than impressed by this "alarming rate of increase," for India is apparently adding the population of a Spain or even a Poland every decade At first glance, this annual addition of five millions appears proportional considering that India's population is about a fifth of the total world population. As we have seen already, some have been so stunned by this "terrific torrent of babies" that they make us all tremble before the amazingly dismal prospect of having to begin the next century with more than 700 million souls within the geographical confines of India. We can not, of course, possibly foretell what the population of India or any country will be in any distant

future, for we can not foretell possible changes in current trends But we can tell what the population will be any number of years hence on the basis of current, recent or assumed trends in the birth and death rates and several other factors which affect the growth or decline of a country's population. Therefore, before we allow ourselves to be impressed by these alarming estimates and forecasts, let us look into the causes, nature and significance of this growth What then does account for this steady increase in India's population?

An Explanation of This Growth

Several factors—sociological, economic, social, political and religious—account directly or indirectly for this growth The first, though not the foremost, factor is the comparative peace that India has been enjoying for nearly a century. Before the establishment of British rule, no part of the country enjoyed any prolonged period of peace unbroken by wars, pestilence or famine In fact, these unstable political and economic conditions were partially the result of the British, French, Dutch and Portuguese imperialist-cum-commercial efforts to establish economic and political supremacy in India. What with these foreign invaders' periodical visits to loot India, the native rulers of India easily took sides and the result was civil wars, though they were not as frequent as those in China But once the British rule was established with force of arms, comparative peace was also maintained, partly by force of arms and partly by virtue of their political ideals. Thus, for nearly a century India has been enjoying peace and tranquillity, if these terms could be defined as the sum total of averted wars.[15] For a long time India has not been a major theater of war and no great portion of her manpower has been lost through wars comparable to what is happening today on several battle-fronts in the world in the second World War

The second reason, though not a very important one, is the increasing improvement in the census operations of India, which represent a triumph in organization The 1941 census year has been a "peaceful" year, despite the fact that India was technically a belligerent country The last census was also significant, for there was full cooperation on the part of the people with the census authorities. This factor of the nominally present divergence between the interests of the people and the Government of India has often been ignored But this is a very significant drawback, for there has never been in India's history a national or peoples' government at the center. During this last census, everybody made an effort to get into the census schedule The 1935 Government of India Act has enfranchised more millions The people who had become politically conscious thought that getting registered on the census schedule was finding a permanent place on the electoral roll Despite the fact that there was a political deadlock in the country between the British Government and the majority of the popularly elected cabinets in the provinces, there was no major political upheaval in the country to disturb or interfere with the census enumeration. This factor is often ignored, but it is important, for Gandhi's nationwide Civil Disobedience Movement in 1931 interfered with the census enumeration that year to the extent of a recognizable margin of error.

A major factor contributing to this growth, however, is that the last decade has been relatively healthy and even prosperous. On the negative side, no

[15] "We have given India tranquillity and order," the British argue "But it is the tranquillity and order of the cemetery," retorts Gandhi. Both can be correct, depending upon the particular meaning they attach to these words. In a wide perspective, Gandhi's retort is not without justification, of course.

nation-wide or even province-wide epidemic or any such catastrophe laid waste the country. Nor was there any famine comparable in its rigors to those of earlier decades. New political reforms in the provinces, the provincial autonomy—which transferred a substantial measure of political control to the people's representatives and the formation of popular provincial governments by the Congress Party gave rise to several ameliorative and progressive changes in the administration of the country.

These new measures of the popular governments have left their imprint in several fields for the betterment of the general economic condition of the people, though the provincial governments' capacity for good was suddenly cut short by the declaration of the present war There has been some improvement in public health measures in most of the provinces It is true that improved public health policies do not yield immediate and quick returns. While generally they have a delayed effect on the quantity and quality of the people, they have an immediate effect also in the sense of keeping alive persons who otherwise would have died For instance, if cholera mortality in India has been brought down, it means that not only are so many more people now present in the population but many of these so preserved reach the stage of reproduction in the course of a decade If a girl or a young woman is saved from a premature death of cholera, it not only means one soul has been saved, for she continues to live, but she is going to add to the population on reaching the period of reproduction. The marked reduction in epidemic mortality in India for the decade under discussion is in sharp contrast to the decade 1921–31 which bore heavily the results of the influenza epidemic of 1918–20, which accounted for the loss of some twelve millions. This factor partly accounts for the growth of India's population.

The regions which have contributed a substantial number to the All-India population have witnessed in the last decade some striking changes toward improved economic conditions. To take but two examples: the Punjab, which was almost a desert some years ago, has been converted into a smiling garden, thanks to the vast irrigation projects that have been brought into existence in recent years The irrigation development in the Punjab, bringing more land under cultivation, easing thereby the economic tension in the lives of millions, has contributed to an increase in the population not only within its borders, but beyond them as well The Punjab has contributed to the increase in the province of Sindh (17 per cent), Bikanir (38 per cent) and the Bawalpur States (36 per cent). All these regions carry a considerable Punjab contribution to their population The second instance is East Bengal Parts of this region, though not quite desert-like as in the Punjab, were covered with wooded marshes until recent years Reclamation work, irrigation facilities and the flood waters have brought this region controlled water supply and consequently under the plough. This inundating water not only irrigates the land but also brings new soil and fertility; the floods also scour out channels and drains These natural as well as man-made improvements have rendered agricultural operations somewhat more profitable. The result is that this region exhibits a high density of population. The heavy increase in population in East Bengal has also contributed to a rise in the population of Assam, Cooch-Bihar and other adjoining areas

Besides these ameliorative and progressive measures, there are certain sociological factors that partly explain this decennial increase in population. In India, unlike any country in the west, an overwhelming majority of the population is found to be in the married state.

This by itself does not mean much, except that this factor is potentially a favorable one toward increasing the population. Then the common and rather widely prevalent tendency to marry early with a socio-religious sanction behind it has been a helpful factor, albeit limited in its scope, in the growth of India's population.

It may be pointed out here that climate acts as a favorable factor in the growth of a population. In India the girls attain puberty between the ages of twelve and fifteen and, though often physically unprepared, they are physiologically ready to bear children. And cases are not wanting where reproduction has begun at the age of thirteen and fourteen. The Report of the Age of Consent Committee and the All-India Women's Conference Report have estimated that more than forty per cent of the girls married in India are below the age of fifteen. The girls marry as soon as they reach puberty, begin begetting children early, reduce the period of lactation, thereby shortening the intervals between child-births with the disastrous final result of a premature grave. The very low level of living, the absence of prolonged period of education or training, the existing social attitudes that encourage a large family, the joint family, the want of nation-wide contraceptive clinical service and above all, the psychological reason that encourages every man to look to his wife and sex intimacy as the only relaxation and recreation in an otherwise dull and unexciting life of a relentless struggle to make both ends meet. The very economic instability makes one resigned and fatalistic; thought for the morrow and contemplation of the prospect of a large family are brushed aside. The thought that he can not be worse off than he is banishes all ideas of foresight and control.[16]

How this low level of living, supported by the strict caste system, damages all efforts on the part of the individual to climb up and push on, eventually resulting in a high birth rate, is pointed out by Warren S. Thompson. "In countries like India," he observes, "where capillarity is small because of a rigid caste system, there is no tendency for the birth rate to decline and for population to die out; just as a very solid substance (copper or iron) will prevent any considerable capillary movement in fluids, so a rigid social structure will prevent upward movement in a society and will thus obviate the danger of an individual development becoming so engrossing that the person has not time for the rearing of a family."[17]

A reconciliation with unheard of poverty becomes imminent. All these contribute their share to the higher birth rate and to the growth of Indian population. As for present growth of population, all this is true. We may summarize here the causes that account for the remarkable growth of population generally and particularly in the last two decades:

1. The relative peaceful conditions prevailing in the country.
2. The increasing improvement in the census organization.
3. The gradual improvement in health measures as compared to earlier decades.
4. The control of famines, though not epidemics, and the increased acreage under irrigation.
5. The universality of married state in India.
6 The large percentage of married women to total women in the reproductive group

[16] Dr. Samuel Johnson's remark as to why people marry is of some interest. Russia being mentioned as likely to become a great empire by the rapid increase of population Boswell records Johnson as saying: "Why, Sir, I see no prospect of their propagating more. They can have no more children than they can get. I know of no way to make them breed more than they do. It is not from reason and prudence that people marry but from inclination. A man is poor; he thinks, 'I can not be worse, and so I'll even take Peggy.' "—Boswell's *Life of Johnson.*

[17] Warren S. Thompson, *Population Problems* (1942), p. 39.

7. The comparatively early age at which reproduction begins.

8. Ignorance of the existence as well as the unavailability of cheap and reliable contraceptives.

9. The influence on certain Indian social institutions like caste and the joint family on the birth rate. The joint family serves as an incentive to higher birth rate because it does not insist on the economic stability of the husband as a prerequisite to marriage. If the Babu family should survive, many Babu babies should be born!

10. The psychological drive—the incredible poverty and the low level of living which offer no pleasure in life save that of sexual intimacies.

But let us look into future trends. All this may seem that there is nothing to stop this deluge of brown babies. Some have been so impressed with these factors, favorable to growth, that they make all kinds of forecasts of India bursting with people in a few decades! But let us look deeper into some of these vital factors that decide the addition as well as the reduction of India's population. But before we speculate on the possible future growth or static character or decline of India's population, we must examine a few of the chief characteristics of Indian demography.

Universality of Marriage

The major factor of Indian demography is the universality of the married state in India. For the last fifty years, the proportion of the married to the unmarried has not changed and today India has the lowest proportion of unmarried to both sexes. "In 1931, 407 males and 493 females out of every thousand were married; taking widowers and widows, ascetics and mendicants into account, this means that almost every person of marriageable age was actually married."[18]

[18] Gyan Chand, *India's Teeming Millions.* p. 134.

In western countries, romance (you don't marry some one until you are actually in love with him or her), economic considerations, prolonged period of education and training, eagerness for personal and social advancement—all these contribute to postponement of marriage to a comparatively late date. Religion not only does not condemn celibacy, but has a kind word for it. The current social attitudes do not disapprove of those who never enter the married state. So many do not marry just for the sake of marriage. The pressure of these considerations may even and does often result in many remaining spinsters or old bachelors

But in India there is no chance of love playing any significant part in marriages. Marriages, by and large, are arranged by the parents and the majority are just herded into the married state. Economic stability of the bridegroom has never been a primary consideration in contracting a marriage. Of course, the parents-in-law are anxious to see that the son-in-law is not unemployed, but his unemployment is not a positive disqualification. The resources of the joint family being available for the support of the newly married couple, economic stability of the husband or the couple has never been seriously considered a prerequisite in getting married. Religion does not encourage celibacy, for a Hindu, if he be a strict one, must have at least a son. But it is not really the fear of religious ostracism that is behind this urge to get married. It is the disapproval of society as such that should explain the universal prevalence of the married state.

Sex Composition

The sex ratio has several important socio-economic bearings. Women generally have a lower death rate than men because nature has equipped them better to meet diseases. Organically it is man that is the weaker vessel. So if

women are less than half the total population, the crude death rate of the whole population will be affected unfavorably. The scarcity of women sometimes leads to prostitution and other social problems, though apparently it may seem paradoxical how any society that can not provide mature brides for all its adult men could spare some women for purposes of prostitution

The following table shows the sex composition of the Indian population for the last eight censuses This situation in India—the striking deficiency of women—is in sharp contrast with several European countries and the United States, where males are scarce comparatively.

FEMALES PER 1,000 MALES

Census year	1881	1891	1901	1911	1921	1931	1941
Females	950	960	960	950	950	940	930

Relative scarcity of females has been a striking characteristic of India's population within the knowledge of her regular census history According to the 1941 census, there were only 934 females for every 1,000 males, as compared to 940 1,000 in the 1921 census. Dr J. H. Hutton, the Census Commissioner for 1931, observes: "The figures of population of India by sexes show a further continuation of the steady fall in the proportion of females to males that has been going on since 1901 The female infant is definitely better equipped by nature for survival than the male, but in India the advantages she has at birth are probably neutralized in infancy by comparative neglect and in adolescence by the strain of bearing children too early and too often " He also admits the faulty enumeration of females as a contributing cause in giving low figures for the female population, though this source must account for only a very small error.

The figure is for All-India and the sex ratio varies from province to province. The disparity is least in the Madras presidency. The proportion of females to males becomes less as one proceeds from south and east to the north and west of India. Let us look into this phenomenon a little more closely.

Several factors explain this striking paucity of females in the total population The social attitudes in the country are such that a female baby is looked upon as a liability, whereas the male baby is welcomed as an asset This attitude arises out of certain obscurantist factors inherent in the Indian socio-economic order So a girl in her infancy is treated with a wholesome neglect—neglect nevertheless. Care and attention in her upbringing, especially when beset by infantile ailments, are conspicuously absent. Then there is the simple natural fact that more male babies than female babies are born And why this is so can not be examined here, for this biological trait has some undefined relation with climate, diet, race, social institutions and the pursuit of values

There are certain regional conditions affecting death rates which afford a partial explanation of this sex ratio As Radhakamal Mukerjee points out, "In the plague regions of India, the malady appears to bear more severely on females than on males. Similarly, in malaria-haunted zones, malaria appears to exercise a selective lethal influence on women. On the whole, where economic pressure is more severe and the women are exposed to the hardships of struggle with the soil and climate, as in the zones of precarious rainfall, there is a striking and permanent paucity of women."[19]

Early marriages, if not quite child marriages, worsen the initial balance of births in favor of male babies. This early marriage is generally expected to increase the birth rate. On the contrary,

[19] Radhakamal Mukerjee, *Food Planning for 400 Millions*, p 234.

the effect is often the very opposite The ratio between males and females in the age group 0–5 is favorable to females, but is gravely upset by early marriages, because of two undesirable features of Indian demography. One is the terrific maternal mortality and the other the ban on widow remarriages As for maternal mortality, the figure is shocking: "One hundred out of every thousand girl wives are doomed to die in child-birth" On the average, 200,000 mothers die every year during childbirth or from ailments connected with it. More common than this death of young mothers is the death of women during a little later period of maternity—between 25–35 These deaths are brought on by the physical exhaustion, the nervous breakdown which follows in the wake of premature childbearing.

The second major factor that explains the paucity of women is the social ban on widow remarriage More than 15 per cent of the women of the reproductive age (15–45) do not generally reproduce, for they lose their husbands long before they reach the end of their reproductive period This means that about twelve million women do not participate in active motherhood Some of them do not taste the fruits of sex intimacy at all—for they are virgin widows and the existing social attitudes do not encourage their marrying again! And some of those who have experienced marital happiness are suddenly deprived of their husbands while still young Their normal physical cravings, whetted by initial and inviting experience, are left unsatisfied. The consequent emotional poverty in the lives of some millions of young Indian women can not be adequately expressed in any sociological terms. A few do escape the social disapproval by indulging in clandestine sex intimacies with men who are not their husbands. But this is quite different from approved prostitution and so, when discovered, the social tyranny that descends upon the erring individual is unbearable. This grave injustice to the normal and healthy development of Indian womanhood serves as a preventive check to the population, by withdrawing potential mothers from participating in reproduction. This institution of "socially sterilizing" the widows results in certain undesirable features in Hindu society. While widows, irrespective of age, are prohibited from marrying again, widowers, of all ages, are permitted and do marry Now this double standard of morals created and maintained by the Hindu male results in considerable disparity in age between the average married couple. Since most widowers marry and since they can not marry widows, they have to seek wives among girls very much their juniors If a forty year old widower wants to marry, he can not marry a woman aged thirty, for a woman at that age is either already married and living with her husband, or a widow He can not marry even a girl of twenty, for she may be already married, due to early marriage. So he will have to marry a girl below twenty, anywhere from fourteen to eighteen. This unequal combination from the point of view of age itself, leads to increasing numbers of widows. For the old husband soon passes away, leaving behind his very young wife, a widow And she can not marry, of course. In brief, unmarried and widowed Hindu men have to take brides of any age that they can get Young men of twenty to twenty-one as well as older men of forty to fifty have to choose brides from girls aged thirteen to twenty, roughly. The natural result is that some of these girl brides survive their much older husbands. The paucity of females keeps up the custom of early marriage for girls Early marriages lead to considerable disparity in age between husbands and wives. This difference in age increases widowhood Since widows can not remarry, widowhood increases the shortage of eligible brides, which

means, of course, the paucity of females. Thus the vicious wheel whirls on.

Another factor that worsens the situation is the caste system. This institution can not be discussed adequately in this paper, but it must be pointed out here that caste enhances the already difficult situation of scarcity of females In caste, the field of choice for brides and bridegrooms is definitely limited. In a particular caste it is possible that there may be comparatively more females of the reproductive age than males of the same age group. As men from other castes can not marry these surplus brides, the problem of every adult male finding a bride of a suitable age in his own caste becomes acute.

The caste system affects the situation adversely in another way, also. If we may accept the results of some recent studies, excessive masculinity in the sex ratio of a population group must be taken as a result of inbreeding. Caste, with its insistence on endogamy, promotes inbreeding. This inbreeding partially explains the deficiency of females in the Indian population. Though this phase of the problem has not been examined in detail with reference to conditions in India, it may be a possible explanation.

This uneven sex ratio does not make for social repose or communal harmony. Apart from the dysgenic effects of ill-matched marriages, it leads to graver problems The marked increase in abduction of women—not kidnapping for the sake of ransom money—in recent years, particularly in Bengal and the Punjab, has created one of the disquieting social problems in India, though its gravity has consistently been minimized.

These facts are not new. Every census report harps on the same tune. They are discussed, debated and decried by all enlightened Indians There are any number of individual social reformers and progressive associations working for the abolition of these evils. But progress has been slow and slender. A great leeway, therefore, has to be made before any substantial results can be achieved.

The Rural-Urban Ratio

A formidable reason why reform has been slow in this direction is to be found in another characteristic feature of the Indian population It is the rural and urban ratio composition of the Indian population. An overwhelming majority of the Indian people live in about 700,000 villages This feature of a vast majority being a rural population presents several obstacles on the path of reform. It is true with almost every country that the rural population is agricultural and feeds the nation, but generally enjoys fewer benefits from the governmental services compared to the urban population. In towns and cities people follow non-agricultural and money-making pursuits like industry, commerce and trade and liberal professions and have ready access to comforts, conveniences and luxuries that are beyond the reach of the rural population. Whoever has heard of an agricultural millionaire living a life comparable in any way to that of an urban industrial magnate? Even from a broad cultural point of view, a nation's political, social and educational movements that constantly stir the people into thought and action center around the cities. Most of the nation-building services are concentrated in the urban areas. Large general hospitals, specialized and advanced clinics with the latest equipment, universities, colleges and seminaries, recreational facilities like parks, sports, games, swimming pools and public utilities like gas, electricity and water—are all within easy reach of our city population.

The Indian census, unlike the American census, makes no clear-cut definition of an urban area. In most cases the decision is left to the superintendent of the census districts. But it is usually taken that a rural area is one whose

population does not exceed 5,000. Villages which have a population of more than 5,000 people are classed as towns and towns with 100,000 or more inhabitants are termed cities. The following table reveals how little progress has been made toward urbanizing India:

THE RURAL-URBAN PERCENTAGE OF POPULATION OF INDIA

Census year	Rural	Urban
1872	91 28	8.72
1881	90.59	9 41
1891	90 54	9 46
1901	90 21	9 79
1911	90 65	9 35
1921	89 70	10 30
1931	89.00	11 00
1941	Figures not available.	

IMMOBILITY OF THE POPULATION

Several factors, social, economic and religious, distinctive of Indian economy, can be cited to explain not only the meager growth of cities but also the existence of comparatively few towns and cities in India The most striking explanation of this phenomenon is, however, to be found in the general immobility of the Indian population In no other country is the population so immobile as in India. The comparative stay-at-homeness of the Indian people is a regular feature of many an Indian Census Report In all censuses, nearly ninety per cent. of the people have been enumerated in districts in which they are born Another five per cent is enumerated in adjoining districts which are more industrialized or urbanized than the district of their birth. In 1901, only 9 27 per cent of the total population was enumerated outside the district of birth. In 1911, this percentage fell to 8.7, and in 1931 the ratio was repeated. Though exact figures are not yet available for 1941, there is no reason to expect any radical change, for during the last decade there has been no significant inter-provincial migration. The volume of such migration that has taken place is so small that it hardly affects the above ratio.

The economic reason for this immobility is simple. As the majority of the people are wedded to an agricultural life and since land is the chief source of sustenance, the average Indian can not possibly leave the farm on which he was born and wherein he works. It is not that agriculture in India is such a paying proposition that it renders rural exodus impossible, but the absence of a better calling to take its place. In India, agriculture is not just an occupation; it is a way of life. Then there is an incredibly large rural indebtedness that chains the peasants to their mortgaged homesteads. Even if the average agriculturist is ready to forsake his traditional calling, what alternative is there for him to make a living? Availability of, as well as adaptation into, a new vocation is neither easy nor smooth.

Certain social factors also contribute to this essential home-loving character of the Indian people Caste and other social institutions render severance from home village or town uncomfortable Migration to another province or even to a city may mean an unfamiliar life among people—albeit Indians—who may speak a different language, eat a different kind of food and have different habits and customs

Finally, migratory tendencies are exhibited largely in small units of population. The smaller the unit of population, the greater the proportion of persons born elsewhere. The fact that India shelters nearly a fifth of the human race militates against any free mobility of the population, though this may seem paradoxical.

LITERACY

What about the educational composition of this population? We can not go into this question of education at any length. We can only touch the problem of literacy in India. What with the

great majority of the population being rural and with the absence of a national network of rural schools, the problem of literacy in India has proved to be a formidable one.

A proper comparison of literacy figures must be based on specific age groups. Infants and children up to four or five years must be excluded in any calculation of literacy figures. What is more, the real task ahead of any country is to make at least all new arrivals literate and to ignore those above fifty or sixty years of age who are illiterate But such calculations are not possible with the limited data of age groups that are at our disposal for the present population. For the total population as a whole, however, the percentage of literacy has been improving. There were only 80 literates per 1,000 in 1931, as against 120 per 1,000 according to the 1941 census. Literacy has been defined by the Indian Census Authorities as the ability to read and write a post card in one's mother tongue This increase in literacy is noticeable particularly in Bombay, Central Provinces and Travancore. This figure of 12 per cent. literacy does not show the differences between males and females in this regard. Male literacy has always been higher than female literacy in India. In the 1941 census, the gross figure of 120 literates for every 1,000 of total population is made up of components of the order of 195 for men and 52 for women

Let us look at this Indian progress in a world setting Half of the human race, that is, considerably more than a billion people, can neither read nor write About a third of these illiterates are under the Union Jack in India. The percentage of literacy in India, of course, seems to show gradual increase from census to census. Between 1921 and 1931, she gained one per cent. of literacy and between 1931 and 1941 she gained four more per cent. But the present figure of 12 literates per 100 is really not an improvement, if we forget percentages and look into total figures. In 1931, in round figures, we had 23 million literates (23,484,200) and in 1941 the number rose to 47 million (47,322,700). That is, during the last decade, 23 millions more were made literate, showing a flattering increase of 101 5 per cent But the illiterates increased, too, and more so than the literates. In 1931, we had 315 million illiterates and in 1941 the figure rose to 341 millions—despite the percentage increase in literacy. The simple answer to this is the high birth rate and the absence of concerted measures to make the people literate. Roughly, India must make 35 millions literate within a decade if she wants to keep up with her birth rate In other words, India must make 3 5 millions literates every year to hold her own, but actually only about a million become literates We can not stop the growth of population, nor is it advisable merely on this score We must have more schools and teachers to take care of the new arrivals, at least

We need not go into any elaborate comparison of literacy figures between India and other countries of the world. But we must point out what has been achieved elsewhere among conditions that were comparable to India's. Between the two World Wars, Russia has taken magnificent strides in this respect. Under the Tsarist Russia, before the end of the last war, 78 per cent of the Russian population was illiterate. To-day, twenty-five years later, in the Soviet Union less than eight per cent. are illiterate. The American rule in the Philippines has an equally good record. In forty years of American rule in those islands, illiteracy was cut down from 98 per cent. to 45 per cent. India, after nearly two centuries of British rule, has made no improvement to deserve the word "progress"

Religious Composition

The proportional strength of the main religions in India—an ordinary feature

of formal demography—has become in recent years a major bone of contention in national political squabbles and even in international political relations. The fact that the people of India profess several religions from Animism to Zoroastrianism often threatens to disrupt Indian political life and encourages separationist tendencies Today it has almost driven a wedge in an otherwise tolerably homogeneous character of the Indian population. This religious composition has also brought into existence, unfortunately, a pseudo-minority problem. But happily, unlike in Europe and in America, this minority problem is not a racial one. In all democratic countries, political development has been on party government based on political and economic ideologies Thus, we have communists, conservatives, democrats, laborites, socialists, etc And a communist or a conservative may be a Catholic, Protestant, Moslem or agnostic In India, unfortunately, political parties (except the leading, progressive and representative Indian National Congress) are based on religious affiliations Thus, some Moslem democrats, socialists and communists are encouraged to get together into a political party, like the Moslem League Some Hindus of all economic and political ideologies get together and call it the Hindu Mahasabba These religious parties go on proliferating into further groups on principles that will amaze any political scientist This reactionary feature of Indian political development has gathered strength in recent years to the extent of threatening the very geographical unity of India Several historical-cum-cultural factors can explain this obscurantist development. A future historian may speculate on apportioning the blame to the British government in India, separate electorates, communal franchise, intransigence of certain Indian political leaders, economic tension, cultural conflict down to a mere fight for jobs. Unfortunately, a detailed study of this fascinating but painful subject is beyond the province of our discussion. This has been said because to the average western reader, the question of religious composition of the Indian population is inextricably tied up with the Hindu-Moslem problem, Hindusthan vs. Pakisthan and other -stans and a score of other minor maladjustments of Indian political development.

Apart from this artificially injected political import, the religious makeup of the Indian population is of some interest from a demographic point of view. Different religious groups may have different differential birth rates. Differences in religion may mean in some countries differences in language and even nationality, though this is not true of India Educational levels, economic security and occupational distribution may be explained to a limited extent on the basis of religious differences Several interesting questions may be explained in terms of the religious composition of a particular population unit. Why do the Hindus and Catholics have a higher birth rate? Why do the Moslems dominate the hides, skin and leather industry? Why do the Parsees have the higher percentage of literacy and have the highest percentage of population supported by industries? Why are the Sikhs such good fighters and skillful mechanics? All these questions may be answered from a religious point of view alone

A study of the last six census returns reveals that roughly out of every hundred persons in India, 68 are Hindus, 22 Moslems, 3 Buddhists, 2 Animists, 1 Sikh and 1 Christian. Of the remaining three, one may almost be a Christian, the other on the verge of being a Buddhist and the third probably a Jain. The following table gives the percentages of population that profess the chief religions of India.

RELIGIOUS COMPOSITION

Religion	Percentage						
	1881	1891	1901	1911	1921	1931	1941[20]
1. Hinduism	74.3	72.3	70 4	69.4	68.6	68.2	65.7
a) Buddhism	1.4	2.5	3.2	3.4	3.4	3.7	2.5
b) Jainism	0.5	0 5	0.5	0.4	0.4	0.4	0.4
c) Sikhism	0.7	0.7	0.8	1.0	1 0	1 2	1.1
2. Islam (all sects)	19.7	20.2	21.2	21 3	21.7	22.2	24.2
3. Christianity (all denominations)	0.7	0 8	1.0	1.2	1.5	1.8	1.4
4. Others	2.7	3.2	2.9	3.3	3 1	2.5	4.7

[20] Based on provisional figures only.

WHAT OF THE FUTURE?

What is likely to be the future growth of this population? Will it continue to grow, or remain stationary or tend to decline?[21] On certain assumptions and on the basis of current trends, forecasts may be made on the probable population figure say in 1951, when the next census is due. But such a forecast is unnecessary for our purpose here. We discussed in the foregoing pages certain major features of Indian population and any peep into the future must be based on the realization of the importance of these features. Whether these factors are desirable or undesirable need not detain us here. We take them such as they are, as demographic facts. We have not made any detailed examination of crude or corrected birth, death or survival rates. Nor have we discussed the age composition of the population or the net reproductive rate. All these are beyond the limited scope of this paper. But on the basis of the chief and somewhat unique features of Indian demography we can draw certain inferences not of present trends but of future growth. In drawing such an inference, we must recall that:

[21] An excellent discussion of some aspects of this question may be found in P. M. Lad on "Population" in *Economic Problems of Modern India*, ed. R. Mukerjee.

1. The majority of the population is rural.
2. The married state of the adult population.
3. The paucity of females and the decreasing proportion of women to the total population.
4. The relatively smaller number of women at the reproductive age.
5. The low specific fertility of these women.
6. The large number of widows who are not expected and do not generally remarry.
7. The high birth rate and the high death rate and the unsatisfactory condition of Indian public health.

These do not reveal a desirable state of affairs, but we are interested here only in the influence that these factors will exercise on the future growth of Indian population. The rural population groups have generally a higher birth rate than the urban population groups The second factor of every adult being married is favorable to higher birth rate. These two factors will tend to increase the birth rate. But the cumulative effect of these two factors are more than balanced and even nullified by the other factors, which need no elaborate comment. Before we dream of a devastating torrent of babies flooding the finite Indian countryside, we must grasp the significance of these factors.

BOOKS ON SCIENCE

THE FAMILY ALBUM[1]

A POPULAR account of the heredity of normal human traits might very well, like this one, be organized about a collection of photographs of the individuals of some three or four families over several generations. Such a collection would be particularly valuable if the pictures were taken with that object in mind. Naturally, such an undertaking would have to be cooperative and would extend over several lifetimes.

The alternative, adopted here, is to make a collection of such material as happens to be available. This has been done with a great deal of persistence and skill, and undoubtedly many a reader will find the book of absorbing interest. A wide range of human variability has been covered. This method, however, has the inherent disadvantage that such a collection of photographs, however excellently enlarged and reproduced, will often fail to depict clearly many of the individual's traits that we would like to know. Nor can this defect be remedied, as seems to have been attempted here, by using the same photograph, or enlarged portions of it, over and over. Indeed, little seems to have been gained (except expense) by reproducing a single portrait ten times and another thirteen,—and these two examples are by no means solitary instances—unless it be that the reader comes to recognize certain visages as old acquaintances. Lack of color in the illustrations is another drawback. One must wonder about the assurance with which the eye color of a man who died in 1857 is said to have been homozygous blue. Nor can photographs depict either a musical voice in father or daughter, or superior literary expression found over three generations in one family, or religious zeal manifested in four, although the photographs of these individuals are all reproduced.

Most geneticists will probably feel that the effort to make the subject simple has been carried to the point of vagueness and inaccuracy. Since the exact mode of inheritance is known only in occasional instances, the author is generally reduced to a statement that a trait is passed down from generation to generation, or that it appears to be dominant or recessive, or inherited in a complex fashion. This mode of treatment becomes questionable when we pass to temperamental characteristics, such as love of nature, orderliness, efficiency, and good taste in dress. Although the role of environment in affecting such characteristics as these is mentioned frequently, the impression nevertheless remains that, because they can be shown to run in families, they are to be considered inborn. "Good taste in dress, as well as ability to draw and paint moderately well seems to be inborn" (p. 206). Real evidence that traits of personality may be inborn is not presented here, nor is it emphasized with sufficient force that the recurrence of a trait in a family is quite as likely to result from family traditions and influences or from the effect of a shared environment as from common genetic factors. Pellagra, too, may be shown to run in certain families whose members share an inadequate diet.

One lays aside the book with mingled interest and regret—interest kindled by the portrayal of the common kinds of variability to be found in even a very few families, and regret that our present knowledge of human genetics and the limitations imposed by the reliance on donated photographs leave us with so little of definite value.

H. B. GLASS

[1] *Family Treasures.* David D. Whitney. 299 pp. $3.50. Jaques Cattell Press.

MODERN METEOROLOGY

In these days when most meteorology books for budding aviators are written by amateur meteorologists who have done some flying and taught all phases of aviation, it is refreshing to find an elementary book on the subject written by a professor of meteorology (Imperial College, London). Though the book is written chiefly for R.A.F. cadets, it is a useful introduction for persons having different ultimate applications. The illustrations are, naturally, taken mostly from Britain, which reduces its usefulness for American readers who are not going to northwestern Europe. Still, the principles of meteorology in Britain hold also in America!

Professor Brunt caters to the elementary and more advanced student by listing at the beginning of the book certain pages and lines that the nonmathematical reader may omit. So skilfully is the book written, however, that the omission of these pages does not break the continuity.

The content is an inclusive coverage of modern meteorology: British type of observations and instruments; variations with time of day and with height; average conditions over the globe—general circulation; elementary physics of the atmosphere; the upper air; radiation; water vapor, condensation, precipitation; clouds; visibility; synoptic charts; the typical frontal depression; nontypical disturbances. Each chapter is closed with a few exercises which, however, ask for facts rather than for reasons.

The elementary physics of the atmosphere is stated so clearly and precisely that it is a pleasure to read such statements as: "Air is said to be *saturated* when it would remain unchanged if it were placed above a plane surface of pure water at its own temperature." Equilibrium is illustrated by a marble: in a bowl, for stable; on an inverted bowl, for unstable, and on a horizontal table, for neutral.

The author takes certain liberties with the International Cloud classification, notably bestowing on the new "Nimbostratus" the old confusing definition of "Nimbus" that was abandoned by the International Meteorological Organization. Nimbostratus is the cloud or sheet of falling precipitation itself, not the cloud from which it comes. It is pleasing to find information on the effect of precipitation and of different clouds on visibility, and a distinction between visibility from the air and that from a point on the ground.

While it is hardly worth while mentioning a number of points a meticulous meteorologist might wish to see corrected, one can not pass over the two maps of the prevailing winds over the globe in January and July. The winds here depicted do not correspond to the pressure distribution nor to the descriptions in the text We are surprised to find on the July map: that the prevailing wind over all of North America south of latitude 55 is northerly; that the winds of northern China are also northerly; that the wind sweeps from the Arabian Sea across the southern tip of South Africa and the South Atlantic into South America, blowing much of the way from low toward high pressure. Instead of the prevailing westerlies, all winds south of latitude 35 S are southeasterly, also from low toward high pressure.

The book is recommended to American readers chiefly for the fine presentation of meteorological physics, especially of moisture in the atmosphere and of radiation and its manifold effects. These are the subjects of the author's chief contributions in his comprehensive book *Physical and Dynamical Meteorology.* Also they are least marred from the American point of view by the differ-

[1] *Weather Study.* David Brunt. Illustrated. xi + 215 pp. $2.25. 1942. Ronald Press Company.

ences between British and American techniques The whole book is a well-rounded unit, nevertheless, and well worth reading for a moderately thorough understanding of meteorology in both its scientific and practical phases.

CHARLES F BROOKS

MAN'S BEHAVIOR

No field of medicine or of human behavior is so surrounded by prejudice, misconception and ignorance as that part having to do with mental disorder. Not only is ignorance as such lamentable, but in this case it interferes as well with the welfare and happiness of untold thousands For that reason, Doctor Zilboorg's present volume, a clear and authoritative statement of the nature of mind and its vagaries, serves a most useful purpose.

The author is a prominent New York psychiatrist, an author and medical historian of note, a medical man of wide and deep experience, training, and humanity He speaks with authority and with a polished literary style.

His first chapter (a long one!) he devotes to certain misconceptions, very properly pointing out, in the words of Artemus Ward, that "ignorance does not mean not knowing but knowing so many things that aint so." He discusses the reasons for some of these misconceptions, such as that the neurotic is a weakling, that mental disorder is shameful, that the only real illness is a physical one, that mental disorder is always due to a bodily malfunction, or that all that the incipient psychotic need do to recover is to "get a grip on himself." He defines his terms, emphasizing particularly that the psychiatrist is a specially trained physician, and that psychiatry, though young by comparison, is a specialty of medicine.

He then proceeds to consider the instincts and their manifestations, the role of the unconscious in the causation of mental disorder, the aims of psychotherapy, and the various ways in which aggressiveness is manifested. In a stimulating chapter on "Crime and Judgment" he discusses the reasons for our vindictiveness toward the criminal in relation to the old principle of "noxal surrender" The final chapter, on "Psyche, Soul and Religion," is a clear exposition of the relationship of psychoanalysis to religion. Here Doctor Zilboorg demonstrates the falsity of the loose charge that psychoanalysis is antireligious and that it denies free will in the theological sense; psychoanalysis deals with the psychic apparatus, not with the soul.

The book is a valuable contribution to the growing literature on that ceaselessly interesting topic, man's behavior. It should be read by every intelligent person who is interested in himself and the rest of the human race.

WINFRED OVERHOLSER

[1] *Mind, Medicine and Man.* Gregory Zilboorg, M.D. 344 + vi pp. $3.50. 1943. Harcourt, Brace & Co.

THE VICTORIES OF MILITARY MEDICINE[1]

THE technology of warfare has made obvious and fairly well-known advances on all fronts. Modern planes, tanks and bombs make the destructive power of modern armies immensely greater than ever before. Many of us have some near one exposed to the terrific fire power of our enemies, but few realize how the constructive part of the military armamentarium has kept pace with the rapidly changing methods of warfare. Military medicine is a distinctly specialized field of medicine, although it obviously utilizes and applies to its particular problems the advances of civilian medical science.

A new and extraordinarily well-written book presents an inside view of most of the recent advances of military medicine. It is an extremely stimulating text, enlivened with dramatic but never

[1] *Miracles of Military Medicine.* Albert Q. Maisel. 1943. $2.75. Duell, Sloan and Pearce, Inc.

wildly sensational incidences of the healing power of modern military medicine. The author frankly admits that by the time his manuscript got to press it was probably out of date in certain aspects, for the immense research resources of the United States and our allies have concentrated their efforts on problems of urgent military importance Thus it is not the fault of the author that in a book still damp from the presses, several significant advances have been omitted Among these are very recent studies on the mechanism and prevention of blast injuries (aerial blast and under-water concussion), the application of crymotherapy in the transport of wounded and the remarkable Stader method of fracture fixation

Quite rightly, the history of the development of modern methods in the treatment and prevention of shock is given primary position Shock was probably the cause of more deaths in World War I than any other single complication of injury The dramatic story behind the development of blood transfusions and later the use of concentrated plasma, which may be collected and stored months in advance, is worthy of close attention by any reader who has the slightest interest in the efforts to save the lives of our boys Equally dramatic is Albert Maisel's story of how Dr. José Trueta, a Republican in the Spanish Civil War, proved by an immense series of successful cases, the advantages of the closed plaster cast method of treating compound fractures, first suggested many years ago by the American surgeon, Dr Winnett Orr

The medical story of the holocaust of Pearl Harbor is perhaps the high light of the whole book, for here in an overwhelming emergency, the one group that was not overwhelmed were the physicians of the Army, Navy and civilian Honolulu. In this one battle, three most significant advances of military medicine had their baptism and proved their worth the immense protective value of the sulfa drugs, the life saving power of prompt and liberal transfusion and the value of Moorhead's electro-magnetic locator of foreign bodies

Also described are modern methods for the treatment of burns, improvements in plastic surgery, advances in brain and chest surgery, the application of local anesthesia and, rather briefly, a discussion of tetanus prevention through toxoid immunization There is a separate chapter on aviation medicine which hints at much more than it tells, for it is in this field perhaps more than any other, that fundamental progress has been made There is an excellent description of the very important progress made in the rapid transportation and evacuation of wounded with the minimum of fatigue and exposure

The author wrote so well that one wishes there were more, especially more on military psychiatry and the truly constructive aspects of military medicine which put and keep our troops at such high levels of health and vigor that their own ability to withstand injury and the rigors of modern blitz warfare is very high. Planned, scientific nutrition, immunization against several specific diseases, wiser anti-venereal disease prophylaxis and pre-invasion epidemiologic studies of conditions in far off places have reduced the military sick list to the lowest in history In the Spanish-American War we lost more men from typhoid fever than from battle wounds! We also must not forget the difference between preventing a head wound with a modern steel helmet and treating one which might have been avoided. Military medicine's main concern is to keep as many men behind as many guns as many days as possible Through this comes VICTORY

EDWARD J STIEGLITZ

THE PROGRESS OF SCIENCE

APHIDS

APHIDS, also commonly called "plant lice," are among the best known insects in the world, for in spite of their very small size they are extremely numerous and so have attracted the attention of everyone who grows either flowering plants, trees or vegetables.

These insects belong to the Order Homoptera (same or like wings) along with the scale insects, cicadas, tree-hoppers, leaf-hoppers and others. The Family Aphididae includes the many varieties of aphids. When fully grown these tiny, soft-bodied creatures are, on the average, no larger than pinheads, and show more variety in color than any other insects. Although most often green, some are pinkish red, yellowish, black or brown. They live on the sap or juices of plants and feed by thrusting tiny hollow stylets, like miniature hypodermic needles, into the plant cells in order to suck out the sap.

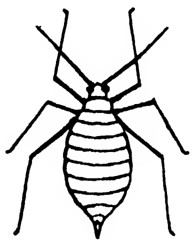
The large numbers of aphids are due to a remarkable reproductive capacity. From eight to ten days after hatching, a female aphid begins to reproduce. This is the shortest life cycle in the animal world, and truly amazing when we compare it to the months and years necessary to produce new generations in larger animals, or even to the weeks necessary for some of the other insects. One aphid may produce from twelve to sixteen young. Each of these begins reproducing in about eight days, thus completing a generation in sixteen days. In Metcalf and Flint's *Destructive and Useful Insects*, we read: "In this way it would be possible, theoretically, for a single female to produce in one year, if all her descendents survived, a chain of aphids long enough to encircle the earth." To appreciate this statement, we must consider a typical life history of these prolific individuals.

When the weather becomes warm enough, aphid nymphs hatch from eggs which have managed to live over the winter. These nymphs, in appearance like tiny adults, are all females which are called "stem-mothers" because they produce great colonies of aphids by the remarkable process of parthenogenesis, bringing forth living young like themselves, without mating. They become "mothers" within a period of less than two weeks, with their numerous children clustered around them. These children are born alive, have only one parent, do not hatch from eggs which have been laid, and are wingless. These, in turn, repeat the reproductive process until many generations have been produced. In these later generations certain ones will grow wings and so can fly to other plants. They, therefore, become known as "spring migrants." These migrants reproduce as stem-mothers starting new generations on new plants and perhaps in new localities. Before the end of warm weather, a generation will be produced which are all winged and are of both sexes, male and female aphids. Being winged, the females (known now as "fall migrants"), often return to the ancestral plants and produce their generations of wingless ovoviviparous young. The young of these fall migrant mothers will not reproduce unless they mate with males of the preceding generation. After mating, the fertilized female lays a few eggs, from one to a half dozen, and then dies. If sufficient shelter for winter protection is provided these eggs they will give rise to the stem-mothers of another spring.

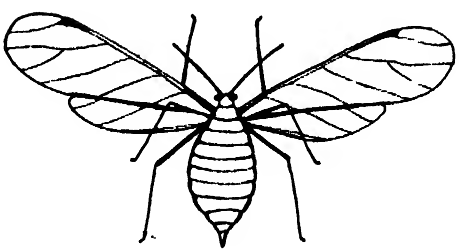
No one has a kind word for the

aphids. They are major pests in gardens, orchards and greenhouses, often occurring in such large numbers as to cause serious damage, if not death, to many kinds of plant life. It is claimed

Aphid in feeding position
Note long beak for sucking
(Greatly enlarged)



Wingless adult aphid
(Very greatly enlarged)



Winged adult aphid
(Very greatly enlarged)

that they are held responsible also for some bacterial and fungus diseases of plants which find a good medium in the sticky honeydew secretion from the aphid's body.

Nicotine used as a dust, or in solution as a spray, is most commonly used in aphid control. This and other means of ridding plants of them are to be found in literature on pest control. Their soft bodies can be destroyed only by a substance which comes into contact with them since they are sap feeders and plant sap can not be poisoned.

There are some insect relatives, however, who could put in a good word for aphids These are certain of the ants, bees, wasps and flies which feed on the secretions of aphids Some ants are said to protect and care for them in order to eat the sweet honeydew secretion which the aphids offer It is claimed that ants may carry young aphids in their mouths not only into their tunnels but to the plants on which the aphids can feed They are repaid for their work by being fed This honeydew secretion is recently discovered to be an extract of the juices which the aphids suck from the plants, is passed through the digestive tract and deposited on the leaves and twigs Being largely cell sap it is good, nutritious food for the insects which have found it.

In contrast to this mutual relationship of ants and others with the aphids is the destruction of them by other insects Among the aphid colonies may often be seen some ladybird beetles, lacewing fly larvae and perhaps maggots of the bee-like fly Syrphus These, when present, are there to feed on the aphids.

It is a pity that such insects as these, and so many others, must be looked upon by mankind with anything but interest, for their life history is one of the most amazing and puzzling in the world of nature. We are not all in a position to know and to appreciate the intimate lives of insects. I like them, but I don't encourage the aphids on my tomato plants because of this interest!

SIBYL A. HAUSMAN

CHEMICAL ELEMENTS NECESSARY FOR GROWTH OF ASPERGILLUS NIGER

INVESTIGATIONS in the Bureau of Plant Industry of the U. S. Department of Agriculture, under the direction of Dr. Robert A. Steinberg, on the mineral nutrition of a mold, *Aspergillus niger*, have proved of general interest. It was known, when work was first begun over twenty years ago, that this fungus would grow in sugar solutions containing ammonium nitrate, potassium phosphate and magnesium sulfate. An apparent necessity for minute traces of iron and particularly zinc was questioned, however.

Heating the sugar solution with calcium carbonate followed by filtration was found quite effective for the removal of the last traces of iron and zinc present The results on growth left no doubt that both iron and zinc are of utmost importance in the nutrition of the mold

Further studies have revealed the necessity of minute traces of other of the chemical elements Claims by other investigators of the need for copper and manganese were verified under conditions of rigid control

Later studies have shown that molybdenum and gallium are also essential for nutrition of Aspergillus. The former element was found to be associated with the capacity for nitrate reduction It was in this connection that a study of nitrogen supply was undertaken and ammonium found to be the form of inorganic nitrogen converted into organic nitrogen

The mold does not appear to need calcium, boron, sodium, chlorine or iodine These elements, with the exception of boron, are required by animals Green plants require calcium and boron.

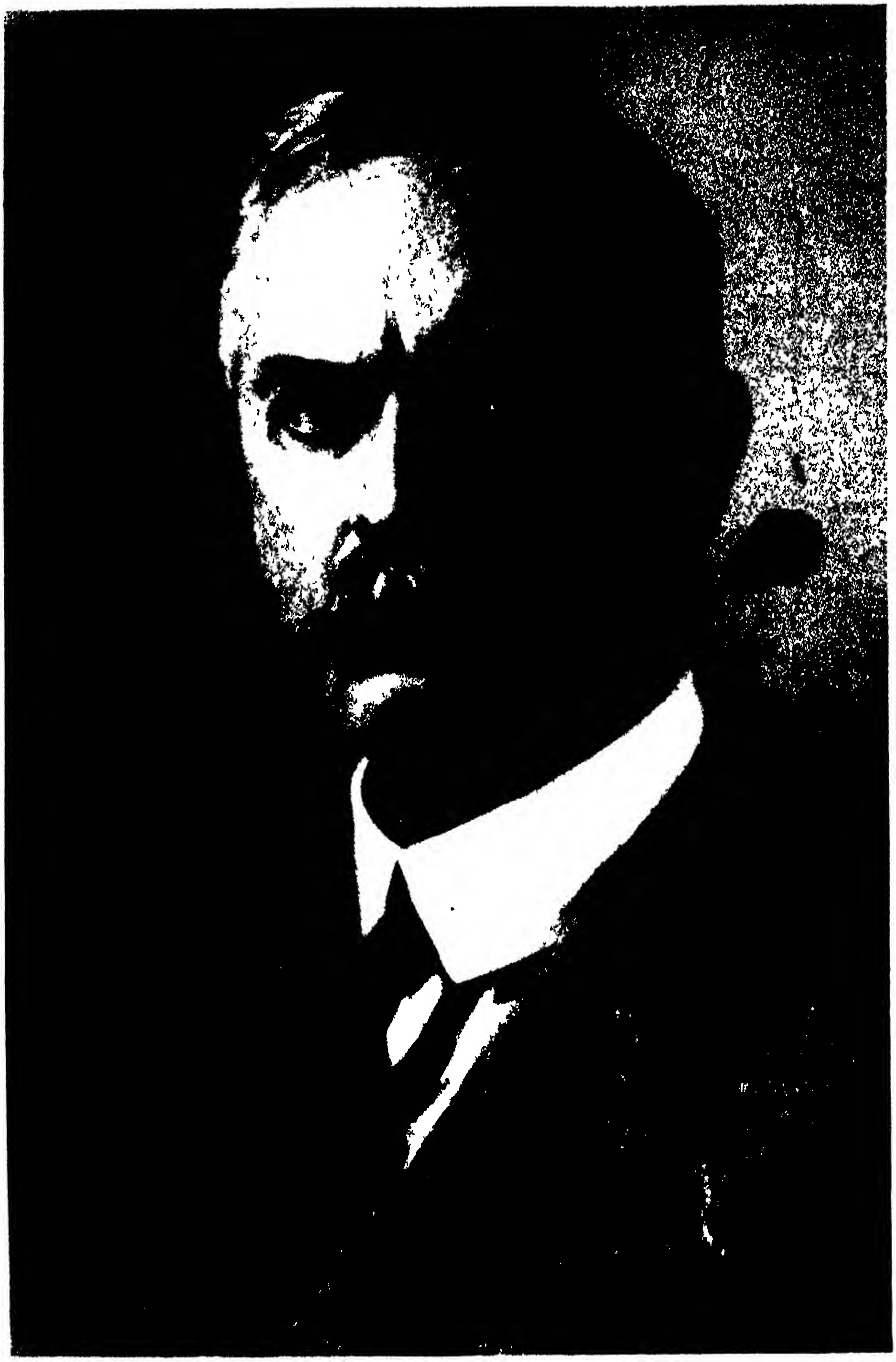
Precision of experimental results has been emphasized. Results in successive experiments have been duplicated to $\pm$ 5 per cent. Almost half the values are within $\pm$ 1 per cent, a high standard of accuracy in biological studies.

The results of these studies are summarized in a new chemical periodic table based on the data of electronic research Both electron number and arrangement are considered, and not electron number alone as in the standard table. Each of the 92 chemical elements has a specific position, whereas the positions of 24 elements in the standard table are indeterminate. Other important features are also claimed.

The most important claims that definite regularities occur in the positions of all the biologically essential elements in this table, whether required for plant or animal These correlations between essentiality and atomic structure lead to the conclusion that essentiality is a property of atomic structure

Four vacancies occur in this table which it is believed should be occupied by elements not yet proved to be essential Scandium, it is suggested, may be one of these The second vacancy would indicate the essentiality of either titanium, zirconium, cerium or thorium; the third of vanadium, columbium, tantalum or protoactinium, and the fourth of nickel, palladium or platinum

Experimental evidence that elements belonging to the vacancies are essential would be final proof, it seems probable, that the necessary elements are a correlated group and not a random selection. Since the chemical and physical properties of the elements are functions of atomic structure, it is not strange that those necessary for protoplasm are dependent for their biological properties upon the same structures. The atomic correlations of the biologically essential elements are an indication of their completely correlated and mutually dependent functions in the cell. This interpretation is in agreement with the facts of biological specificity of the elements, and the complete destruction of the organism in the entire absence of any one element.



DR KARL LANDSTEINER

DR. KARL LANDSTEINER

On June 25, 1943, the world lost a great mind and a great medical scientist when Dr. Karl Landsteiner succumbed to a heart attack Stricken while at work in his laboratory at The Rockefeller Institute for Medical Research, he died two days later at the Rockefeller Institute Hospital. He had just passed the seventy-fifth birthday of a lifetime devoted to fundamental research, whereby he founded and played a guiding role in the development of several important branches of immunology He had just completed the preparation of a new edition of his book, already a classic, *The Specificity of Serological Reactions*, and had also published about three hundred and thirty papers describing the results of his pioneering investigations

Dr Karl Landsteiner, son of Leopold and Fanny Hess Landsteiner, was born in Vienna on June 14, 1868 He entered the University of Vienna in 1885, receiving the degree of M D in 1891 After a brief period of study with the eminent chemist Emil Fischer, he turned to the investigation of bacteriological and immunological problems, his earliest studies being carried out when he held the position of pathologist at the Anatomical Institute of the University of Vienna during the years 1898 to 1908 The years 1908 to 1919 he spent at the Wilhelmina Spital Later he transferred his activities to the R K Ziekenhuis in The Hague, Holland At the invitation of the Board of Directors of the Rockefeller Institute, he came to New York in 1922 and became an American citizen shortly thereafter In 1939, after seventeen years of active service, he was made an emeritus member of the Rockefeller Institute, but he continued working with no less vigor until the day when his last illness overtook him While in Vienna, in 1916, he had married Helene Wlasto Besides his wife, he leaves a son, Dr Ernest Landsteiner, at present assistant resident in surgery at the Peter Bent Brigham Hospital in Boston

Dr Landsteiner is probably best known for his discovery of the human blood groups, frequently called the Landsteiner blood groups in his honor At the turn of the present century, it was recognized that blood from animals of different species can be distinguished by their serological reactions This led to the abandonment of the use of animal blood for transfusions to man, but the much too frequent fatal reactions following transfusions of blood from man to man remained to be explained At this time Dr Landsteiner had just become interested in the problem of the possible existence of individual differences in blood, as well as differences between species Choosing what appeared to him to be the simplest method of investigation, Dr Landsteiner cross-tested the sera from individuals in his laboratory with one another's red blood cells and, instead of the minor reactions that might have been expected, found that in some combinations striking agglutination of the cells occurred while in other combinations no effect was apparent He then established that this phenomenon of isoagglutination was due to two agglutinogens A and B in the blood cells and two corresponding agglutinins in the sera giving rise in combination to the four groups now known as O, A, B and AB Dr Landsteiner's discovery made blood transfusion the safe procedure it is today; it has saved the lives of thousands of persons, many of whom never heard of this famous scientist

Early in his studies, Dr Landsteiner became convinced that there were multiple individual serological differences in human blood At the Rockefeller Institute, he resumed his studies on blood and (with the collaboration of Dr Philip Levine) described three additional ag-

glutinogens of human blood, M, N and P, which, in combination with factors previously described, raised the number of distinguishable classes of human blood to thirty-six. Additional investigations by Dr. Landsteiner and his associates multiplied this figure still further, in particular, his recent description (in collaboration with the writer) of the Rh factor. The Rh factor has been shown to be of importance in certain rare instances of hemolytic reactions following transfusions of blood of the correct group (by the writer), and in explaining stillbirths and a hitherto obscure hemolytic blood disease of the newborn arising from incompatibility of the Rh types of the parents (by Dr. Philip Levine). While this latter work was done by workers who had been associated with Dr. Landsteiner, his inspiration and guidance were in reality largely responsible.

Dr. Landsteiner's discoveries on individual blood differences have found application in forensic medicine for the individual identification of stains of blood and secretions They have proved significant for the science of human genetics because they constitute the best example of simple Mendelian heredity in man, and for the same reason they may be applied in courts of law when problems of disputed parentage arise. They have also found application in anthropology for investigating racial origins, and in veterinary medicine. As Dr. Landsteiner demonstrated from tests on lower monkeys, apes and man (carried out in collaboration with Dr. C. P Miller, and later with the writer), the blood tests furnish evidence of biochemical evolution and "seem to agree with the theory that man and apes are descendants of a common stock, rather than that man evolved from one of the apes"

A problem which early attracted the attention of immunologists was the pronounced specificity of serological reactions. Obermayer and Pick, and later Landsteiner, attacked the problem by studying the effect on the specificity of proteins of their modification by various physical and chemical agents The possibilities of this method of approach were soon exhausted and Dr Landsteiner then attacked the problem in a different way, by devising methods of coupling simple compounds with proteins by diazotization. Dr. Landsteiner, assisted by Dr. H. Lampl, showed that in this way the protein was conferred with a new specificity which depended on the nature of the group introduced into the molecule Carrying this work further at the Rockefeller Institute with his associate, J. van der Scheer, he proved that the specificity of serological reactions in general is determined by the chemical structure of the antigen This important field of immunochemistry, founded by Dr Landsteiner and highly developed by himself and other scientists, culminated with the preparation (by Walther F. Goebel and W T J. Morgan) of artificial antigens which duplicate some of the serological properties of cellular antigens

Dr Landsteiner later became interested in the problem of drug allergy and contact dermatitis, a field of considerable importance in industrial medicine Here the exciting agent is usually a simple non-antigenic chemical or even an element like the metal nickel First working with Dr John Jacobs, Dr. Landsteiner devised methods of inducing sensitivity in animals to some of the chemical compounds causing contact dermatitis in man Then, together with two other colleagues, A. di Somma and Merrill W. Chase, he adduced considerable evidence to show that this depended on an antigen-antibody reaction, and that the exciting agent acquired its antigenic properties by combining with body proteins.

Dr. Landsteiner made fundamental contributions to other branches of immunology, for example, the diagnosis of syphilitic infection He showed that alcoholic extracts of *normal* tissues contained the active principle responsible for Wassermann's test, an observation on which is based the current use of beef-heart lipids as antigen in the test He introduced dark-field illumination for the demonstration of spirochetes, and elucidated the mechanism of paroxysmal hemoglobinuria Dr. Landsteiner also succeeded, for the first time, in transmitting the virus of poliomyelitis to rhesus monkeys, in that way inaugurating the experimental study of that disease

The fundamental significance of Dr. Landsteiner's discoveries was recognized only gradually even by his fellow-scientists, and honors came to him relatively late in life. In 1926 he was awarded the Hans Aronson Foundation prize In 1930, he received the Nobel Prize in Medicine for his discovery of the blood groups, and the same year he received the Paul Ehrlich medal for his chemical studies He was made an honorary member of numerous scientific bodies in Europe as well as in this country; in addition to being made a Chevalier of the French Legion of Honor he was awarded the Dutch Red Cross Medal. At a citation in his honor read on the occasion of the award of the honorary degree of Doctor of Science at Chicago University, he was called, "the world's greatest authority on the mechanism of immunity," and a Harvard citation stated, "he founded a school of thought which has penetrated wherever immunologists are at work."

Apparently unaffected by these honors, modest and kind, Dr Landsteiner continued his work until the day his last illness overtook him Dr Landsteiner's austere life, marked by a continuous series of outstanding scientific discoveries, stands out as a symbol of the progress possible under governments allowing individual freedom and opportunity

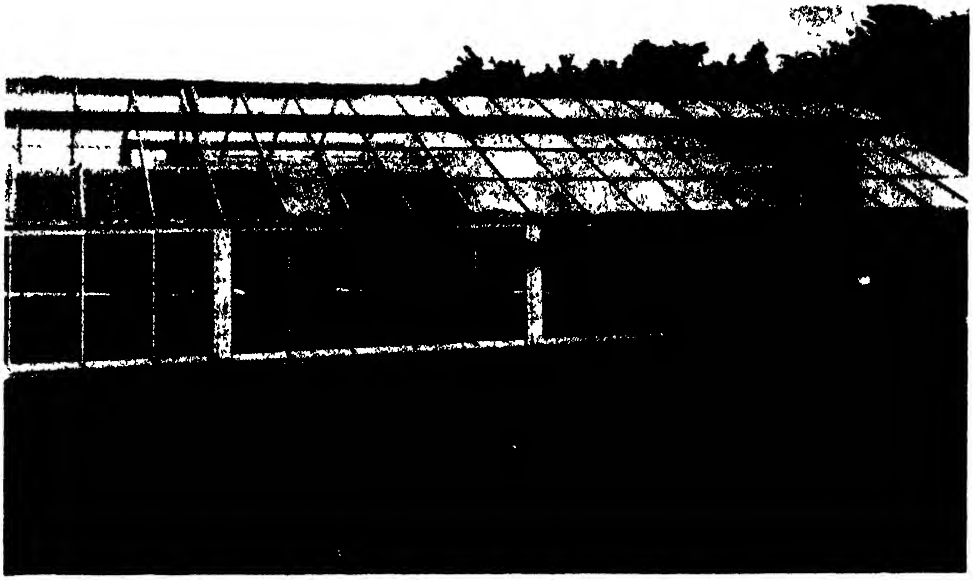
A S Wiener

SOME EFFECTS OF SOIL AND AIR TEMPERATURES ON THE GROWTH OF CERTAIN GRASS SPECIES

Since the geographical distribution of grasses as well as seasonal variations in their growth are strongly influenced by temperature, a more thorough knowledge of the temperature relations of some of the grasses would not only contribute toward the solution of some problems of lawn and pasture management, but would also afford a better understanding of the climatic adaptation of the different species. Under natural conditions climatic factors vary together in such a manner that it is difficult to separate their individual effects. Therefore, the relation of the growth of certain grass species to air and soil temperature was determined in thermo-regulated growth chambers.

The growth chambers, of which there were three, were equipped with thermostatically controlled heating and cooling units designed to permit their simultaneous operation at different temperatures Each growth chamber consisted of a modified soil-temperature tank surmounted by a glass-enclosed compartment, the air chamber, the temperature of which was regulated independently of that of the soil temperature tank. The growth chambers were located within and along the south side of a greenhouse, the long axis of which extended east and west.

Among the grasses investigated were Kentucky bluegrass (*Poa pratensis*), the most important lawn and pasture grass



NORTH SIDE OF GREENHOUSE CONTAINING TEMPERATURE CONTROL UNITS

in the northeastern states, Bermuda grass (*Cynodon dactylon*), the leading lawn and pasture grass of the cotton belt, and orchard grass (*Dactylis glomerata*), a pasture grass which, compared with the above species, is intermediate with respect to its temperature adaptation

The experimental grass cultures, each of which consisted of 25 plants started from seed, were grown in pots 8 inches in diameter and 18 inches deep Since each culture was grown for approximately 8 weeks before exposure to controlled temperatures, the grasses studied were relatively immature, but were beyond the seedling stage The period of exposure to the different experimental temperatures in the growth chambers was also 8 weeks

Both Kentucky bluegrass and orchard grass made considerable growth at an air and soil temperature of 40° F, the lowest temperature used in these studies Bermuda grass, on the other hand, not only made no growth but was severely injured by the 40° temperature The first symptoms of cold injury consisted of a wilting of the leaves as if water absorption by the southern grass were being retarded by the low root and soil temperature

The production of foliage by bluegrass increased as the temperature was elevated by 10° intervals from 40° to 90° F, although it is probable that the optimum temperature for top growth lies somewhere between 80° and 90°. The optimum temperature for root and rhizome growth, however, was 60° At an air-and-soil temperature of 80°, root growth in the lower soil levels—8 to 16 inches deep—was almost completely suppressed, and at 90° there was no increment in the dry weight of roots Therefore, the depressing effect of soil temperatures of 80° or above on the growth of Kentucky bluegrass observed under natural conditions is probably due largely to the retarding effect of the super-optimal temperature on root growth

The optimum temperature for top-growth by orchard grass was 70° F..

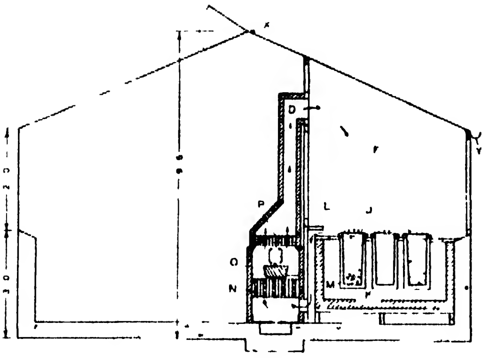
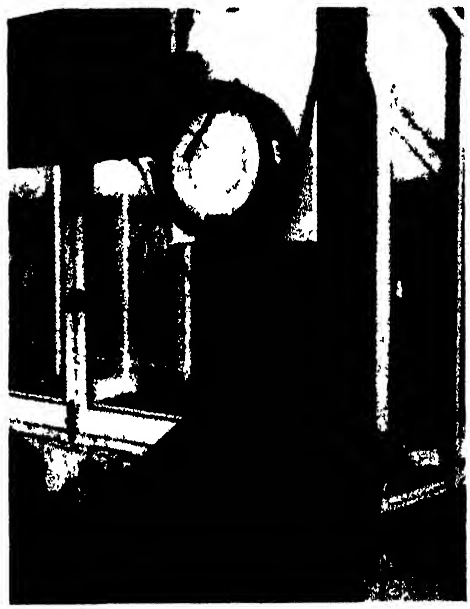


DIAGRAM CROSS-SECTION
OF GREENHOUSE AND TEMPERATURE CONTROL UNIT D, AIR DUCT, F, AIR CHAMBER, J, SOIL CONTAINER; K, SOIL TEMPERATURE TANK, L, BAFFLE OVER AIR OUTLET, M, SLEEVE, N, COOLING COILS; O, FAN, P, ELECTRIC HEATER.

although growth within the temperature range of 50° to 80° did not vary much in this species However, a further rise in air-and-soil temperature to 90° resulted in a sharp decrease in shoot and foliage production by orchard grass Root growth increased as the temperature rose from 40° to 60° and was maintained with a further elevation to 70° Although total root growth was less at an air-and-soil temperature of 80° than at 70°, root development in the lower soil—8 to 16 inches deep—was much larger than in the case of Kentucky bluegrass at the same temperature This difference in root growth at 80° in the lower soil levels may explain the observed fact that under natural conditions the growth of orchard grass is not reduced as much or as quickly as that of Kentucky bluegrass by temperatures of 80° or above. However, at the 90° temperature, orchard grass, like Kentucky bluegrass, made practically no root growth.

The growth rate of both the roots and the tops of Bermuda grass, which made no growth at an air-and-soil temperature of 40° F and very little at 50°, increased with each 10° rise in temperature to and including 100°, the highest temperature employed. At the latter temperature both bluegrass and orchard grass suffered severe injury In fact, 95 per cent. of the orchard grass plants were killed by 8 weeks of exposure to the 100° temperature, but less than 10 per cent. of the bluegrass plants failed to recover when removed to a more favorable temperature

A high soil temperature—100° F—was much more harmful to bluegrass and orchard grass than a high air temperature When these grasses were exposed to a continuous air temperature of 100° F for 8 weeks with the soil temperature tanks maintained at 70°, the grasses not only remained normal in appearance but made some growth



INTERIOR OF GREENHOUSE
SHOWING TEMPERATURE CONTROL UNITS

These studies are being continued both in the greenhouse and in field plots

E. MARION BROWN[1]

[1] Agent, Division of Forage Crops and Diseases, Bureau of Plant Industry, U S. Department of Agriculture, and the Field Crops Department, Missouri Agricultural Experiment Station, cooperating.

POWDER METALLURGY

SCIENTIFIC literature has recently shown revived interest in the oldest art for the production of metallic instruments—powder metallurgy. This is quite natural, for in the last thirty years we have witnessed great strides in the development and understanding of metallurgy and metallurgical processes, as well as in their application in modern industry.

The history of the development of this art is interesting. It began with the Egyptians, as early as 3000 B.C., who left iron instruments made from iron ores reduced to metal by heating in contact with charcoal to incandescence by the aid of bellows. The resulting sponge iron was then hammered while hot into the shapes desired. Such instruments have been examined by modern metallurgical methods and found to be quite free from slag and impurities, and they compare favorably with iron products made by fusion. It must be remembered that there were no furnaces for melting metals at that time and no ceramic materials in which to melt them.

Relics of Ecuador have been examined and found to consist of particles of platinum bound together by gold and silver which form a low melting point alloy. These articles have been assigned to a period dating back before the discovery of America, and were formed in much the same manner as those made by the Egyptians.

During the eighteenth century Wollaston produced platinum from metal powder made by the ignition of ammonium platinic chloride. He placed the powder into a tapered mold and used water to settle the powder so that it would be level and of uniform density. He then inserted a plunger into the mold and applied pressure to the plunger by means of a toggle press, thus forming a compact mass that could be removed from the mold and handled without danger of breaking. It was then gently heated on a coke fire to drive off the moisture. It was next placed on quartz sand, covered with an inverted refractory pot, and heated in a wind furnace for about twenty minutes. The compact mass was removed while hot and hit with a heavy hammer. After this forging action, the metallic particles were sufficiently welded together to permit further working. Even at this late date, there were no furnaces or ceramic materials available to permit the fusion of such a high melting point element as platinum

It has been only within the past thirty years that Dr W. D. Coolidge, of the General Electric Company, invented ductile tungsten. E. G Gilson, of the same laboratory, invented a porous bronze bearing consisting of a mixture of copper, graphite, tin, and sometimes lead and zinc N. H. Adams, also of the General Electric Company, invented copper-impregnated tungsten used widely as electrodes in spot and line welding Heinrich Baumhauer and Karl Schroeter, of the Osram Lamp Company, in Germany, developed cemented-tungsten carbide, after which hot-pressed cemented-tungsten carbide was developed in the research laboratory of the General Electric Company, and several other mixed carbides, such as tantalum carbide and tungsten carbide, tungsten carbide and titanium carbide, and tungsten, tantalum, and titanium carbides cemented together with cobalt Balke, of the Fansteel Company, developed a tantalum carbide material cemented with nickel. George Taylor, of the General Electric Research Laboratory, developed diamond-impregnated, cemented-tungsten carbide for wheel dressers and oil-well drills. Goodwin H. Howe, of the same laboratory, more recently invented the sintered alnico magnet material generally composed chiefly of iron, cobalt, nickel, and aluminum.

All of these materials are made from metal powders pressed together in a

mold to form a compact mass of the desired shape and size and then heated in a suitable reducing atmosphere to bond the particles together.

Recently the automotive industry has developed the use of cheap iron powder in the manufacture of many parts demanding lubrication, such as bearings, washers, cams, oil pump gears and door catches. They have used oil-impregnated bronze bearings for years This industry is ideal for the application of powder metallurgy, since its product has many small parts that require lubrication. Oil-impregnated bearings can be turned out by automatic machines by the million, sintered in atmosphere-controlled, continuous-operating, automatic temperature-controlled furnaces where the pressed compact goes into one end and the bearing comes out the other, finished except for the oil impregnation However, in many cases where the tolerances are close, a cold-coining operation is required; that is, a resizing by restriking the sintered product in a die, or a final sizing by finish grinding or machining.

Iron parts to which carbon or graphite has been added may be sintered by heating to a temperature sufficiently high to bring about diffusion of carbon or graphite into the iron-forming steel Iron may be bound together with copper in the same manner. The parts containing carbon may be heat-treated as are steel articles made from fused metal that has been cast and worked.

Many applications do not require material with high physical properties, but only lubrication to prevent wear The porosity of the compressed compact is controlled by the amount of pressure applied and the temperature and time of sintering, and sometimes volatile compounds are added to aid in maintaining porosity.

Pressed powder materials with high tensile strength, high density, and greater ductility may be made by heating the sintered compact and applying pressure. This process, however, has a very limited use for much trouble is experienced with seizure in the mold, excessive die wear and die cost.

Pressed powders sintered at temperatures close to the melting point in a suitable atmosphere for a sufficient length of time show strengths comparable to cast materials of the same composition. Compacts of iron, cobalt, and nickel sintered in this manner have been produced with the theoretical densities for these elements. Sintered powder mixtures or alloys have been produced having the characteristics of a casting of the same composition, and when hot-worked, have all the characteristics of a wrought material produced by melting, casting, and forging.

The term *sintering* as applied to powder metallurgy has had various interpretations, but, in general, the meaning of this term is the bonding together of particles facilitated by the application of pressure and heat. Many things happen during such an operation. The microscopic particles of powder on pressing become bonded together by interlocking and seizure. During heating, the small particles crystallize and form grains; then these grains begin to grow, the larger ones absorbing the smaller. During this grain growth, the small particles rearrange themselves, taking on the orientation of the grains which absorb them Surface tension at temperatures close to the melting point causes the particles to draw more closely together, shrinkage takes place, and the voids between the grains gradually disappear with time until the sintered mass becomes a solid aggregate of grains firmly bonded together.

Powder metallurgy is ideal for mass production methods because with a single die, a pill machine and a suitable atmosphere, temperature-controlled, continuous-furnace small parts can be turned out by the thousands. Elements with

high melting points, such as tungsten and molybdenum, may be sintered and hot-worked at a reasonable temperature into any desired form. There are no ceramic materials in which to hold them even if they could be melted

One of the greatest advantages of the process is due to the fact that porosity of a sintered compact can be controlled, thus making it possible to impregnate it with oil and use it as a bearing, which, in many cases, demands no additional lubrication

High melting-point elements or compounds can be mixed and bound together by the fusion of a lower melting element, such as cemented-tungsten carbide or copper-impregnated tungsten Powder metals and alloys can be pressed to any desired shape and size and sintered without any machining or waste of material Pure metals can be mixed in any desired proportion and sintered without danger of the contamination that often accompanies melting

Many small parts, intricate in shape, which would be very costly if made by machining or casting, can be made less expensively by sintering A casting might be very brittle and non-workable, while the sintered product would be strong and not so brittle An example is sintered alnico magnet material. The size of sintered articles can be very accurately controlled by a cold coining operation, and sintered metals can be produced with physical characteristics entirely different from those produced by any other method

There are, however, some disadvantages and limitations to the sintering process The cost of metal powders is inherently greater than that of metals used for melting, and in some cases many times greater, and the physical properties of sintered materials are lower than those of wrought materials of the same composition. The cost of dies is so high in cases where only a few parts are required that it is prohibitive.

Powders when pressed do not flow around corners as do many plastic materials. On that account the design of the part to be formed is very important The plungers operate in straight lines, and in order to withdraw the plunger or eject the compact after forming without breakage of the compact, the design of the die and compact must be correct

Many automatic machines of the pill machine type are used today to turn out small parts As the size of the part increases, the machine tool cost increases greatly Many of these large machines are hand operated and the cost of production is greatly increased

With large parts, the material cost alone in many cases prohibits their use Large parts are difficult to produce to size and shape due to the non-uniform distribution of pressure in the compact during pressing which results in non-uniform shrinkage and distortion upon sintering.

The present activities of metallurgists and the wide use of money and materials for the further development of this very old art are bound to bring some new inventions, new applications, and further development of the industry. It is not a cure-all, however, for metallurgical and mechanical needs It fits into its own niche which, in many cases, can not be filled at the present time by any other known process The industry has become large, the value of a single year's production running into many millions of dollars

The formation of committees by some of our national scientific societies would be of great service by stimulating interest in the future development of sintering and by supplying the consumer with the much needed information on the characteristics and physical properties of materials made by the process.

F. C Kelly

THE SCIENTIFIC MONTHLY

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WIND AND SOIL

By Dr. WILLIAM HERBERT HOBBS

EMERITUS PROFESSOR OF GEOLOGY, UNIVERSITY OF MICHIGAN

WIND has been responsible for the removal of soils, as the recent history of the "dust bowl" abundantly testifies Far more important, however, is the role that wind has played in the creation and deposition of soils. Probably at least ninety per cent. of the richest soils in the "granaries of the world," have been transported and deposited by wind, though to a considerable extent they have been later redeposited by water The teeming millions of humans in China, British India and Egypt dwell on wind-derived soils. The most concentrated populations live upon deltas at the mouths of great rivers; but the soils which alone permit of such dense populations were first collected by the wind before their deposition by the rivers. Still other great areas of rich soil, such as those of the Ukraine in southern Russia, the wheat and corn belts of our own Middle West, and the Pampas of the Argentine, owe their existence to glaciers, running water and wind; the wind, however, *after* instead of *before* the deposition by the water.

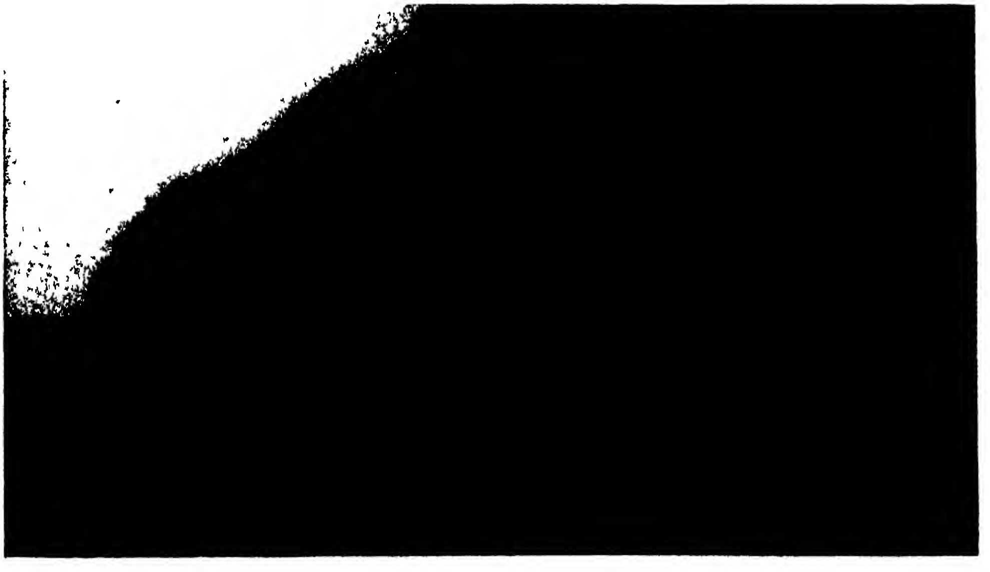


FIG. 1. DUST STORM ADVANCING ON KHARTOUM

Soils are of necessity finely divided; that is to say, they are in powdery form, produced from coherent rock material

FIG. 2 PEBBLE PAVEMENT
IN THE LIBYAN DESERT OF NORTHEAST AFRICA.

either by some abrasional process or by chemical decomposition Fine subdivision of a solid is a necessary prerequisite to the solution process, and in the laboratory the chemist accomplishes this with the use of mortar and pestle. The principal natural agents of abrasion are glaciers and wind, each with the aid of rock material used as a tool It is in deserts that sand driven by the wind is able to abrade exposed rock masses; wind-deposited soils fall into two categories according as they are glacier derived or are of desert origin.

Water must be present in soils in order that they may supply food to plants, but the percolation of water through soils by dissolving out, or leaching, their soluble ingredients brings about their impoverishment. This loss is in addition to that which is removed by plants. In humid regions, therefore, where much water passes through the soil, nitrates, phosphates and salts of potash must be periodically added in order to make up for the losses by these processes

All wind-derived soils have come to be known under the general name of *loess*, a word of German origin, meaning loose or open-textured Due to their pervious structure loess soils take up the water of rains, as does a sponge, to produce a slightly plastic mud

On the continents of Asia and Africa deposits of loess have been derived from the great deserts which cover vast areas of the interior, whereas in Europe and the Americas loess is mainly of glacial origin before its deposition by the wind

Desert areas are walled in from the

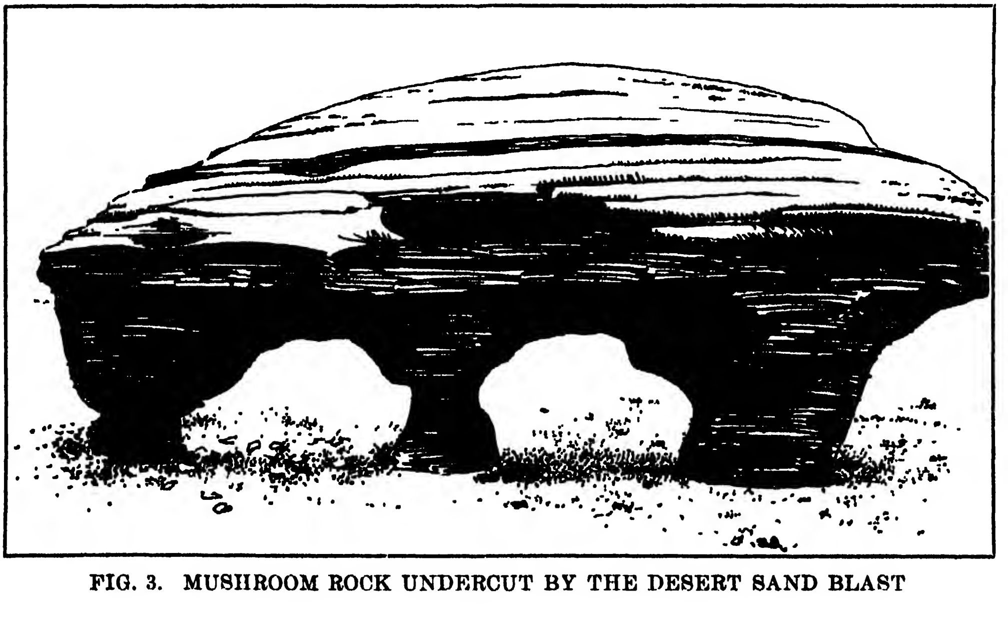


FIG. 3. MUSHROOM ROCK UNDERCUT BY THE DESERT SAND BLAST

prevailing winds by ranges of mountains, at least on the windward side, and it is to this fact that they owe their aridity The mountains force the moisture-laden winds coming in from the sea to rise and give up their charge of moisture as rain which falls on the outer mountain slopes In Asia the hinterland is fully walled in on all sides by gigantic mountain systems, but the aridity of the great Libyan desert of Africa is brought about by the Ethiopian Highland and the Red Sea Hills, which cut off the south-east trades from the Indian Ocean The Sahara desert is due to the Atlas ranges to the north which act in a similar way on winds of the north temperate zone coming in from the northwest To the south and west the Sahara is without important mountain barriers, but these areas are on the leeward sides of the interior desert from which the soils are transported by the wind

Although there is a widely prevalent notion that deserts are vast areas of sand, yet the greater part of their surfaces are of hard rock The heavy sand deposits are largely restricted to the leeward areas that are walled in by mountains Dunes of sand are also built up far from the borders wherever there are eddied

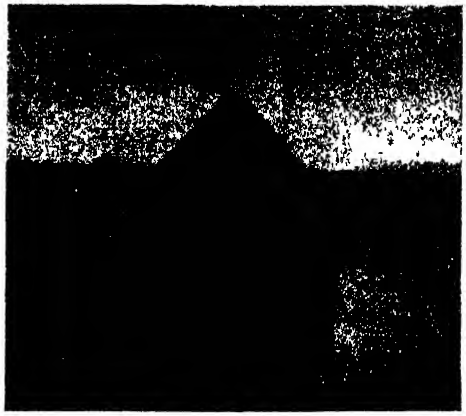


FIG 4 ADOBE POST

AT MARKAZ EL SHERIKAH, IN THE LIBYAN DESERT, WHICH HAS BEEN UNDERCUT BY THE SAND BLAST. FIVE YEARS FROM THE TIME THIS PHOTOGRAPH WAS TAKEN IT WAS AGAIN PHOTOGRAPHED AND DISCOVERED TO BE HALF CUT AWAY NEAR ITS BASE

areas, as on the leeward side of basins of special rock excavation (Fig 10) The breakdown of the desert rock into dust, sand and larger rock masses is first accomplished mostly through large and sudden changes in temperature between day and night At midday, under the desert sun, the air temperature may be as high at 150° F. At such times the hand cannot be held on an exposed rock

FIG. 5. ISLAND OF GRANITE NORTH OF KHARTOUM

WITH A DEFINITELY DELIMITED LOWER ZONE, ABOUT A YARD HIGH, POLISHED BY SAND BLAST.

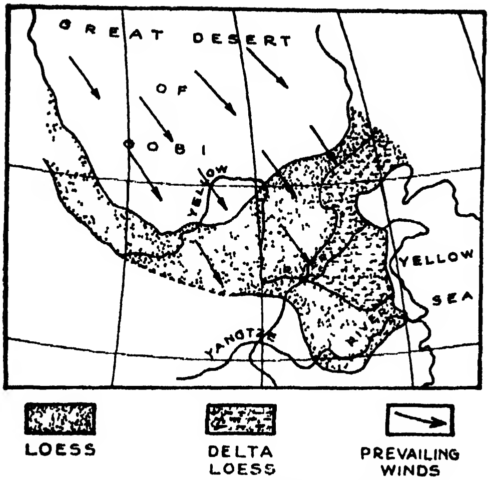


FIG. 6. MAP OF LOESS DEPOSITS
LAID DOWN IN CHINA BY NORTHWEST WINDS FROM THE INTERIOR DESERT MUCH OF THE MATERIAL, YELLOW IN COLOR, WAS GATHERED UP BY THE YELLOW RIVER AND DEPOSITED IN ITS VAST DELTA REGION WHERE IT FLOWS INTO THE YELLOW SEA

surface, yet night falls suddenly at sunset and one must hurry to get into his blankets, for freezing temperatures may quickly follow Under these conditions of surface expansion and rapid contraction of the rocks the surface peels or scales off in pieces of pebble size or larger. But more remarkable are the sudden temperature changes when one of the rare and heavy rains occurs. A cloudburst at midday—it is usually at that time—often splits open rock masses several feet in diameter, much as boulders are sometimes broken up by farmers by building a fire on all sides of them and dashing water over them.

The winds which sweep with great violence over deserts pick up the smaller rock scales, and eddies even lift fragments some inches in diameter and drive them hopping along the surface. There are left behind only those rock fragments that are too large to be moved by the wind. Thus is produced the "desert pavement," or "pebble pavement" (Fig. 2). This pavement carries other special names, such as *sêrir* in the North African desert and "gibber plain" in arid Australia

Coarse sand is carried along near the ground by the hopping motion, or saltation, but the finer sand rises and attacks men mounted upon camels. It is the coarser sand near the ground which accomplishes the principal work of abrasion on the rock of the desert surface This sand blast process yields the bulk of the dust which is carried out of the desert to form the loess deposit. The desert winds rise suddenly and advance as dust storms with an opaque and terrifying front (Fig 1).

The effectiveness of sand bombardment during a dust storm is beyond the imagination of one who has not observed it A tin plate exposed through a sand storm has the tin removed; a bottle similarly exposed is given a ground glass surface. Iron telegraph poles in North Africa are polished by a single storm to a height of about a yard from the ground, indicating the level to which the saltational movement extends. During an exposure of only a fraction of a year the

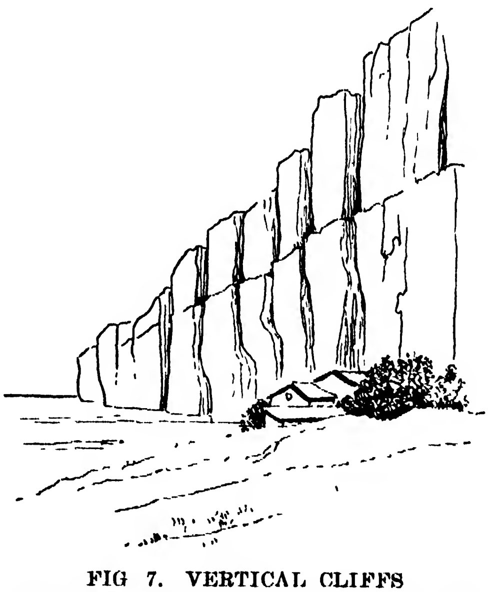


FIG 7. VERTICAL CLIFFS
FORMED OF LOESS ALONG THE YELLOW RIVER.

FIG 8 CANYON IN LOESS OF CHINA
SUNKEN ROADS CUT BY CENTURIES OF TRAFFIC

adobe corner of a cemetery within the Great Oasis of the Libyan desert was cut away on the windward side to a depth of six inches a short distance above the ground. But only a yard above the desert surface not even the veneer had been removed (Fig. 4). This sharp falling off of the effectiveness of sand bombardment above the height of a yard or so explains the "mushroom rocks" so common in deserts (Fig. 3).

"Islands" (*Inselberge*) of hard rock which rise above the general level of the desert floor show polish by the sand blast, and this polish is sharply limited at a height of about a yard (Fig 5) The sand blast extends much higher, of course, but its effects are produced at a much slower rate

Wherever marginal mountain barriers exist on the leeward side of deserts, sand is built up in a vast area of dunes on the inner side of the barrier The mountains themselves have their angular contours rounded off by this veneer, and their valleys and canyons are in part filled by the finely divided loess The dust, however, is carried out over the mountains to the watered areas outside. For it to be retained where it falls, it is necessary that there be at least a thin grass vegetation Otherwise, it is again picked up by the next storm wind and is carried farther to leeward. The most extensive, as well as the heaviest, loess deposits in the world are those in China, which were derived from the desert hinterland lying to the northwest beyond the mountains (Fig 6). In places they have

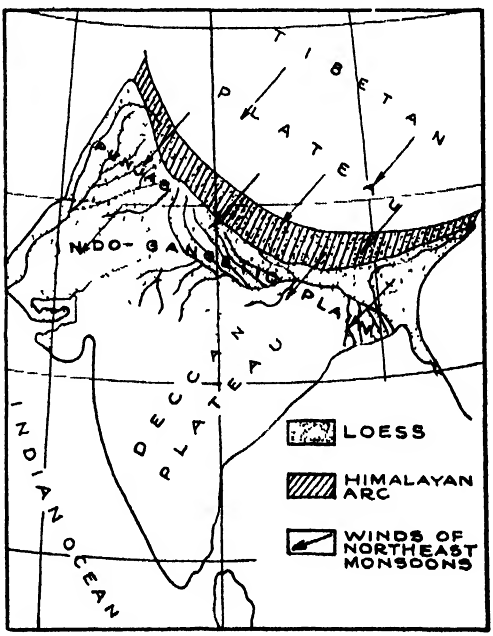


FIG 9 DEPOSITION OF LOESS
MAP TO SHOW THE DEPOSITS IN BRITISH INDIA.

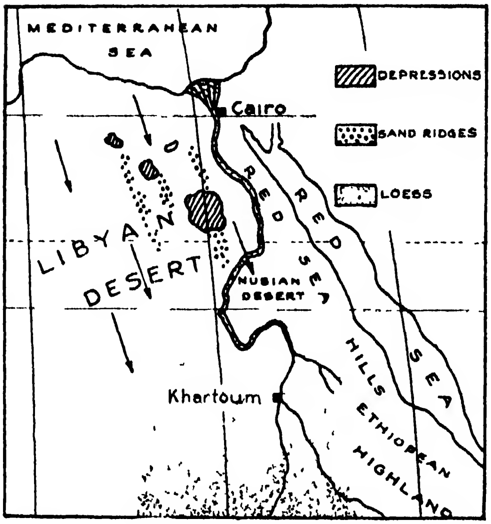


FIG. 10. MAP OF EGYPT

AND A PART OF THE ANGLO-EGYPTIAN SUDAN, SHOWING THE PLACE OF ORIGIN OF LOESS SOILS AND THEIR ROUTE OF TRANSFER DOWN THE NILE VALLEY TO THE DELTA WHERE THE RIVER DISCHARGES ITS LOAD INTO THE MEDITERRANEAN SEA.

a thickness as great as 600 feet Except where it has undergone extensive change from the weather, loess is yellow-brown in color; the marked yellow of the Yellow River and Yellow Sea is explained by the suspended loess

The yellow color of loess is by no means its only marked characteristic There are a number of others which are always present, no matter in what country the loess is found or whether it is of desert or of glacial derivation One of these properties is a vertical parting, or cleaving, habit, which causes the deposit to present vertical cliffs (Fig 7)

Loess deposits the world over have an internal, fine, tubular structure which permits capillary upward movement of water carrying dissolved salts which restore lime to the surface soil. This structure of loess is explained by the grass blades and roots around which the flying dust became entangled and held. After organic material decomposes, it leaves the vertically directed, porous structure.

Equally characteristic of loess is a firm though weak cementing quality, due to lime, which permits excavations in it of cave-like habitations by local populations. Not only in China, but in almost every loess deposit throughout the world, such habitations are made by the poor. Though a ceiling to a cave holds well so long as it is not disturbed, scratching with the fingernail is sufficient to destroy the cement, and the material thus disintegrated is not again recemented Whenever the destruction of loess structure occurs where winds prevail, the loess powder is carried off and a hollow results The traffic of men and animals along roads over thick deposits of loess in the course of centuries gradually transforms these highways into deep canyons (Fig 8) Though China pre-

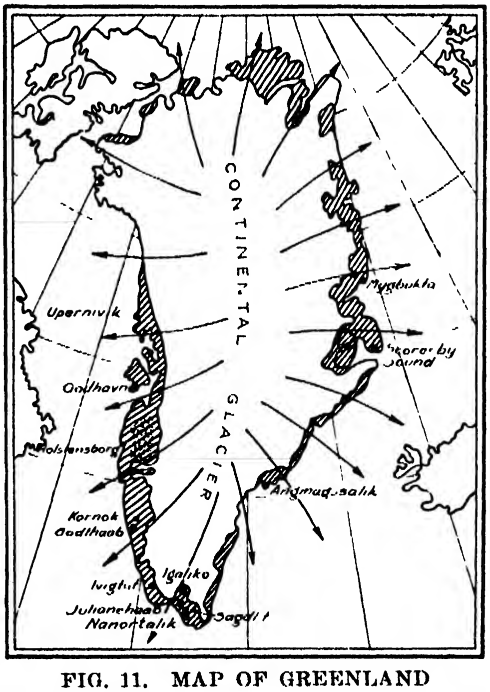


FIG. 11. MAP OF GREENLAND

SHOWING THE AREA (800,000 SQUARE MILES) OF THE CONTINENTAL GLACIER (WHITE) AND THE PATTERN OF THE WINDS OF THE GLACIAL ANTICYCLONE (ARROWS). AN AREA OF LOESS DEPOSITS IS SHOWN IN THE SOUTHWEST, EAST OF HOLSTENBORG, WHERE THERE WAS A RESEARCH STATION.

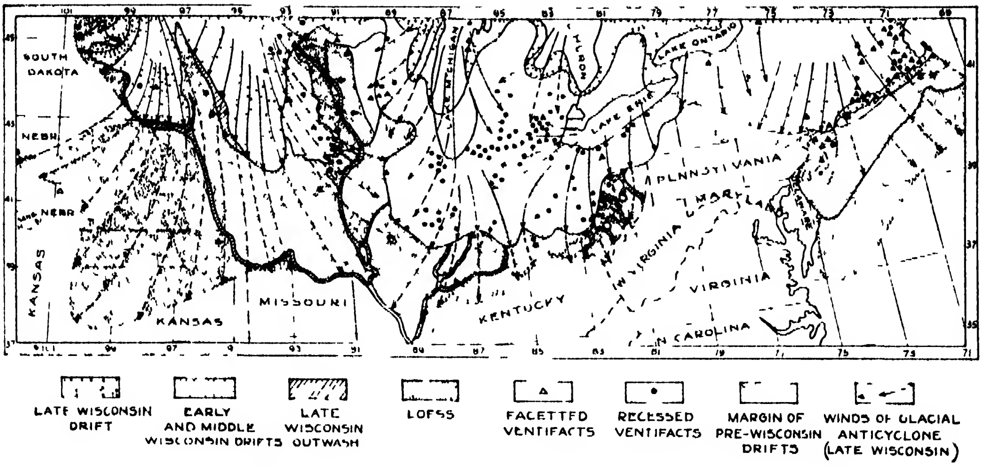


FIG 12 MAP OF PART OF THE NORTHERN UNITED STATES

SHOWING THE AREA WITHIN THE UNITED STATES WHICH WAS COVERED BY THE LATEST PLEISTOCENE CONTINENTAL GLACIER AND THE LOESS DEPOSITS WHICH WERE BUILT UP AROUND ITS BORDERS

sents the outstanding examples of sunken highways in loess, others of lesser depth are to be seen in all loess deposits wherever there has been a civilization

Other qualifying marks of loess are lime concretions which are due to the separation out of the lime in the deposits These concretions assume fantastic figures which have given rise to the names *Loesspuppen* (loess dolls), *Loesskindel* (loess children), and in China, "Stone ginger."

Though no distinct horizontal layers can be made out in loess because of its fine texture, the lime concretions often seem to be in horizontal "banks," as are sometimes other materials The land origin of these deposits is attested by the enclosure of fossil land snails and bones of vertebrates (mammals), while artifacts betray the evidence of man at the time the deposits were laid down. Loess soils are thus quite generally of Pleistocene (Ice Age) and recent origin

After China the great granary of Asia is British India, which is separated from the interior desert by the lofty Himalayan Mountain arc India has a wet season and a dry season In the former the moisture-laden winds come from the Indian Ocean—the southwest monsoons; the dry season is characterized by dry winds from the desert areas beyond the Himalayas—the northeast monsoons The latter winds have brought dust from the Tibetan plateau, and this has been spread over the southern slopes of the mountains as well as the plains below The great rivers Indus and Ganges have gathered up much of this dust and have deposited it as the fine silt of the Indo-Gangetic delta-plain (Fig 9)

As in China, so also in Hindustan history has been punctuated by almost periodic droughts and consequent crop failures, which resulted in famines and human tragedies surpassing anything elsewhere known In India the British

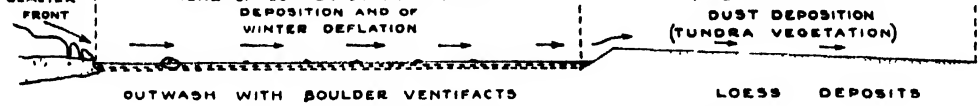


FIG. 13. FORMATION OF LOESS DEPOSITS

OUTSIDE THE OUTWASH AREA AT THE FRONT OF A CONTINENTAL GLACIER, WHERE IT IS THICKEST.

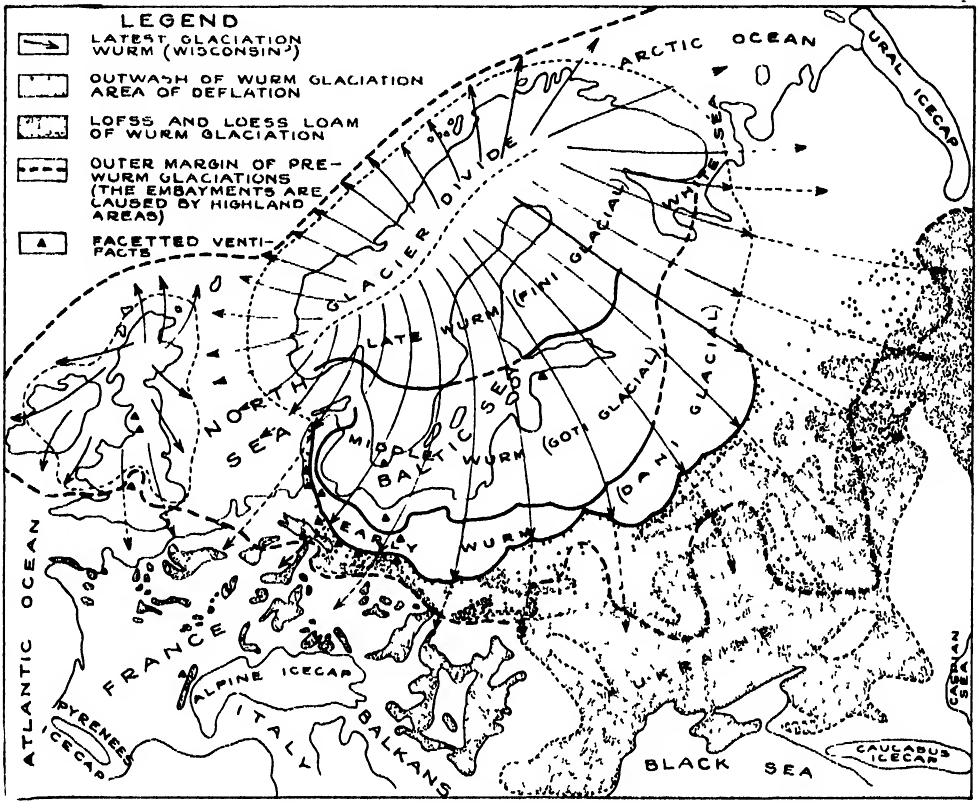


FIG. 14 MAP OF GLACIER-COVERED AREAS IN EUROPE

SHOWING THE BORDER OF THE LATEST PLEISTOCENE CONTINENTAL GLACIER AND THE RICH LOESS LANDS TO THE SOUTH AND EAST, TOGETHER WITH THE EXTENSIVE OUTWASH BELT LYING BETWEEN

Government has successfully met this menace by irrigation and adequate transportation, and now in that land a great famine is a thing of the past British India has even been able from its surplus food to supply the great British armies in East and North Africa The canal irrigation installation of the Punjab, in Northwest India, is now the greatest in the world

The third granary area of the Eastern Hemisphere, and one which supports a dense population, is Egypt, especially the valley and delta of the River Nile The fertility of this region is due to the loess soils deposited by winds in the Anglo-Egyptian Sudan, which lies southward within the tropics (Fig. 10). The Libyan and Nubian deserts, through which the Nile flows as a five-mile wide ribbon of intense fertility, have resulted from the high barrier of the Ethiopian Highland and the Red Sea Hills, which increase in height and merge in the highland to the south This barrier cuts off the moisture-laden southeast trade winds coming in from the Indian Ocean

The prevailing winds of the Libyan desert vary only through a few degrees from the direction North 15° West. They blow over a monotonous rock plateau (*Hamada*) which rises several hundred feet above the Nile Valley and is capped by a hard limestone, the Mokattam limestone, on which rests the citadel in Cairo. This resistant limestone is underlain by soft rock beds which, where locally exposed by breaks and ver-

tical displacement, have been excavated by the wind into cliff-bordered depressions. The depressions constitute the oases of the desert, due to the artesian wells through which rises the Nile water from a deeper sandstone layer (Nubian sandstone). In the lee of the depressions long dunes of sand stretch out to the southward for tens of miles Since there are no mountains to the leeward, the dust carried by the strong north wind is halted only when it meets the first vegetation, which is found about 150 miles to the northward of Khartoum At this confluence of the White and the Blue Niles is the halting place of the equatorial rains that migrate northward with the sun The resulting loess deposit is at first thin, but thickens southward (Fig 10)

To the southward of Khartoum, water is withdrawn from the Blue Nile for the great irrigation installation of the Gezirah, the area within the fork of the two Nile branches These irrigated lands are the cotton plantations of the Sudan. It is to be presumed that loess soils identical with those of the Gezirah extend far westward into the unexploited areas of equatorial Africa, since conditions suitable for their formation are indicated. After the war, when exploration and tropical medicine have together accomplished a conquest of that area, another considerable granary may be added to the world's resources.

It has long been known that in addition to the great deposits of loess in Asia and Africa, there are others in Europe and in the Americas which are clearly not of desert origin Their distribution is such as to indicate a derivation from former continental glaciers, but just how has not until recently been explained Two such glaciers are still in existence, one of them on the Antarctic continent, the other over Greenland The Greenland glacier covers all the land except a relatively narrow ribbon along the coast Recent studies by the University of Michigan Greenland Expeditions have now shown clearly the manner of formation of the loess, which covers considerable areas within the coastal belt of land The Greenland, like the Antarctic, glacier is at all times covered by a fixed wind system of centrifugal pattern, which is known as a glacial anticyclone (Fig 11)

The deposition of the Greenland loess is brought about by seasonal alternation of processes in which running thaw-water and wind play the principal roles within the area extra-marginal to the glacier The glacier itself has quarried and abraded from its rock bed the material that it has transported, and this material is held in suspension within its bottom layers On all warmer days during the brief summer season the glacier thaws on its exposed upper surface near its front, and the melt-water descends to the rock bed through the glacier cracks (crevasses) On the bed the water melts its way out and issues beneath the glacier front, carrying a burden of rock material

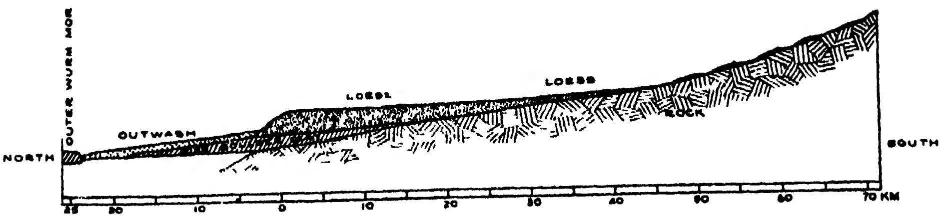


FIG. 15. PROFILE ACROSS OUTWASH AND LOESS DEPOSITS
ALONG A NORTH-SOUTH LINE FROM RIESE TO AUE, IN SAXONY. (BASED ON A PROFILE BY GRAHMANN).

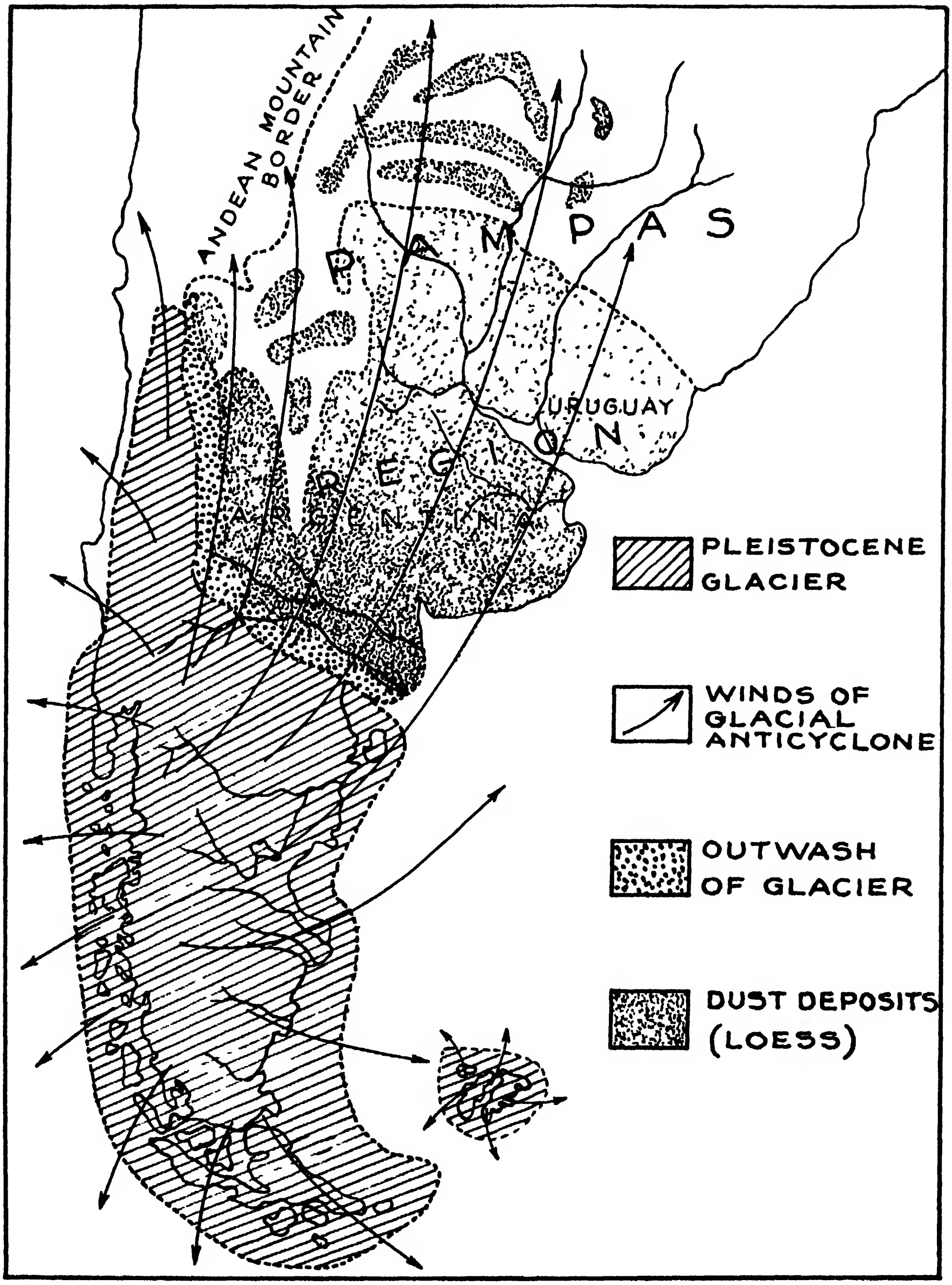


FIG. 16. MAP SHOWING LOESS DEPOSIT AREAS OF THE ARGENTINE IN THEIR RELATION TO THAT OF THE PLEISTOCENE GLACIER FROM WHICH THE LOESS WAS DERIVED

which varies in coarseness from the finest silt due to abrasion up to boulders several feet in diameter By the system of "braided" thaw-water channels, that issue from the glacier front and which on exceptionally warm days are joined to a broad flood, the rock debris is sorted and deposited as it builds up an outwash plain of gravel, sand and silt with enclosed boulders.

At the end of the summer all melting of the glacier is brought to an end for the season, the outwash plain then quickly dries out, and the winds of the glacial anticyclone now take over from the thaw-water the work of transportation and redeposition The sand and the smaller pebbles are lifted and redeposited in irregular hills and dunes, while the silt exists as dust carried higher and farther from the ice front This dust is carried outward and deposited as loess as soon as it encounters a grass vegetation which as tundra begins at the outer edge of the outwash plain. This is because the summer glacio-fluvial floods completely inhibit the growth of vegetation over the outwash plain Loess deposits are thickest next to the outwash area and thin outward (Fig 13)

During the winter the outwash plain has a protective armor of coarse pebbles which is in no way different from the "pebble pavement" of deserts (Fig 2) In the next succeeding summer season the thaw-water takes over from the wind the work of transportation and further builds up the outwash plain, only to be again deflated by the wind during the succeeding winter It should be noted that an outwash plain built up by water that issues from the glacier is a prime essential for the formation of the loess deposit by the wind, and that where the water issues at a level above the bottom layers of the glacier, in which alone the rock debris is available, no loess is laid down. It is also to be noted that the loess deposit is thickest near its source, the

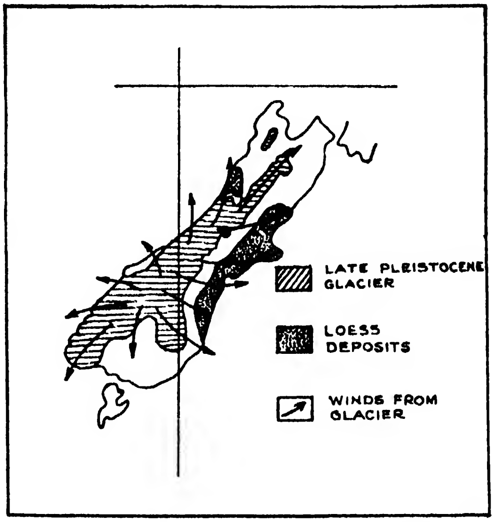


FIG 17 MAP OF LOESS DEPOSITS IN THE SOUTH ISLAND OF NEW ZEALAND, SHOWING THEIR RELATION TO THE PLEISTOCENE ICE CAP IN THE HIGHLANDS TO THE WEST

glacier, whereas loess deposits of desert derivation are thickest far from their source in the desert

The loess deposits which underlie the rich wheatlands of the Middle Western states of the North American Union owe their origin to the latest of the four great continental glaciers of the past, the so-called Wisconsin glacier This latest glacier overlay the northern part of the national domain, as well as most of Canada, during the so-called Ice Age of recent geological history (Fig 12) Similar deposits are probably indicated by the large area of silt on the sea bottom off our Atlantic coast, south of New England, for that area was at the time a part of the continent

Apparently at about the time the Pleistocene continental glaciers lay over North America, quite similar glaciers, likewise four in succession, lay over northern Europe. Bounded along the southern border by an extensive outwash area, loess deposits are spread out over large sections which surround the outwash, and these constitute the rich wheatlands

of Europe, including the Ukraine of southern Russia (Fig. 14). As in the case for the United States, the loess of Europe is thickest nearest the glacier and thins out at greater distances (Fig. 15) The Rhine River which flows through the loess area, has transported this material as fine silt to be deposited along its banks and carried down to the sea, and it has there contributed to the rich delta which has supplied the food to the densely populated region of the Low Countries

The great granary of South America is the Pampas plain of the Argentine, likewise a heavy loess deposit which has been derived from the continental type of glacier that in Pleistocene times covered most of Chile and the Southern Argentine (Patagonia). Here, as in the cases of North America and Europe, the deposits are thickest over the areas close to the outwash, the wheat lands. The loess thins northward where it makes the pasture lands of the Argentine cattle ranches Today the winds blow summer and winter alike from the opposite quarter, or across the Argentine out of the northern hinterland where there is a rainfall of fifty to eighty inches (Fig. 16).

The main granaries of the world have been passed in review and shown to owe their fertility to the wind-deposited loess formations There are also many smaller areas both on the margins of deserts, as in Central Asia and especially Turkestan, and in association with smaller ice caps, as in the plain of Lombardy about the River Po on the borders of the Pleistocene ice cap of the Alps Another interesting small example is supplied by the South Island of New Zealand, where the wheat fields of the Canterbury plain are of loess deposited about the borders of an ice cap which in Pleistocene time lay to the west (Fig. 17)

ACCIDENT FACTS FROM THE NATIONAL SAFETY COUNCIL

FATAL accidents in 1941 were up 6% over 1940 Every 5 minutes, one person is killed and 90 injured in accidents in the U S A , at a total cost of $38,000

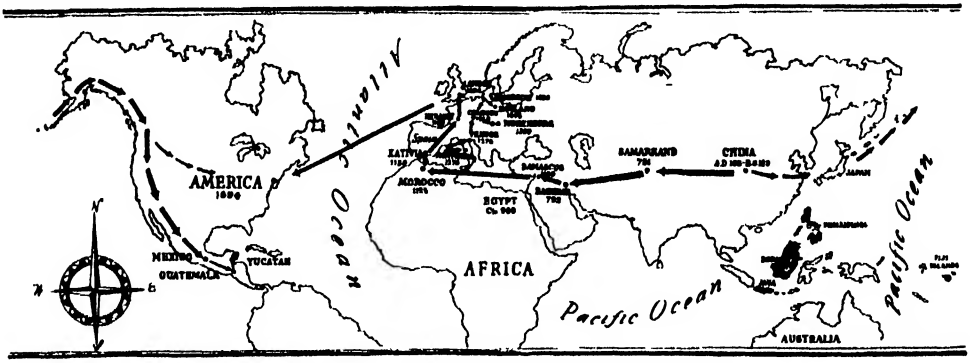
In 1941, there was one accidental death in every 342 families; one disabling injury in every 4 families, and the national cost was $88 a family.

War death, wounded, captured and missing in the year following Pearl Harbor took about 55,000 men. But in the same year, 102,500 died in accidents—one in 1,300 people Injuries were sustained by 9,400,000—one in 14 people Of these 350,000 were permanently disabled and 8,950,000 temporarily disabled.

PAPER AND CIVILIZATION

By Dr. VICTOR W. VON HAGEN
SANTA MONICA, CALIFORNIA

WE live in a paper-world. Paper work—putting a thing on paper—has become the first stage in thought and action As a space-saver, a time-saver, a labor-saver, paper has had a unique part in the intellectual development of mankind. Wherever paper, in any of its variety of forms, has touched the lives of people, it has quickened them, given living substance to their oral traditions and become the means for the creation of literature and fiber of the mulberry, was invented by the Chinese and became the cultural medium of the Asiatics. While across the waters of the Atlantic, an American civilization (during the same period that the Chinese were perfecting their paper) had invented a smooth, white, writing surface, beaten tapa-like from the wild fig tree Those people were the Maya, and their medium was *huun-paper* Eventually two of these paper-worlds,



THE PATH OF PAPER BEGINS IN CHINA
BEFORE THE ADVENT OF CHRIST, TRAVELS EAST INTO EUROPE BROKEN ARROWS INDICATE THE ROUTE OF PROTO MONGOLIC PEOPLES TO AMERICA THERE THE MAYA, PERHAPS EVEN BEFORE THE INVENTION OF "TRUE PAPER" BY THE CHINESE, MADE THE FIRST PAPER FROM MULBERRY FIBERS.

civilization Yet paper did not create its role, and its part as a civilizer was not, in the beginning, a conscious one, like most cultural elements, it began by accident And curiously enough, paper in its broad sense was invented in three geographically separate areas—Asia, the Mediterranean, and Middle America—culture areas remote from each other Yet, in each area and in different forms, paper played its role in the intellectual evolution of people. Papyrus, although it was not paper as we use the word, was the precursor of the paper medium · it was confined to the Mediterranean. Paper, true paper, fashioned from the bast- the Mediterranean and the Asiatic, met and then, with the European as cultural agent, these two absorbed the third—the Maya and the Aztec

Paper and the cultures it helped to create did not follow a steady evolution. At one time, in the fifth century, two of the paper areas faced cultural involution, for intellectual night had settled over Europe. The Goths, repaying with devastating interest an earlier invasion of their realm, had swept down upon Rome and thrown into the decaying foci of civilization the barbaric Alemanni, who undid the cultural work of centuries. Old Roman gentlemen, remembering

with troubled minds their enlightened past, shrank within themselves and dug their noses deeper into the "Consolations of Philosophy."

Greece, classical Greece, was in total eclipse, while the Arabs, their intellectual heirs, were still in a state of cultural pupation. And in this epoch of involution, the Christians, swollen with fanatical zeal, inaugurated the first of their analphabetic crusades—by sacking the Alexandrian library And even in other centers this backsliding went on, for in China the Han Dynasty was breaking up, and this brought on in China, as in the European and Mediterranean theaters, four centuries of cultural anarchy

The lights were going out in Europe and in China, and yet, on the other side of the world, in a region still unknown, still uncharted by men or gods, the Maya, a race of Amerindians, were reaching the apogee of their civilization.

There is no precise moment in protohistory when the curtain can be raised on this civilization of Middle America, nor is there any indisputable moment when paper began to play its role. Starting sometime in the third century, B C, the Maya had, within a few centuries, reared in the jungle the stone cities of Copan, Quiriguá, Ixkun, Holmul, Nakun, Yaxchilan and Palenque Paths were carved out of America's green mansion; trade and commerce were carried on for incredible distances beyond the limits of Mayadom Art and religion with which it was inextricably bound grew, along with their Government, into complex forms Astronomy became highly developed and the knowledge of astronomical time periods, notation systems and the discovery of a permutation system of names and numbers evolved into a complex calendar: the Maya astronomers even discovered the concept of the zero. All this maze of abstract mental activity gave rise, over a long period of time, to a system of hieroglyphs which not only extended their mnemonic processes, but assisted, as it evolved into writing, in the creation of a literature As a corollary to writing, a smooth surface for writing had to be perfected Thus, in some remote epoch of Maya civilization, bark-cloth tunics left the backs of the people and became "paper" This "paper," superior in texture, durability and plasticity to Egyptian papyrus, was thus perfected anonymously and communally by the Maya And this writing surface they called *huun*.

Paper gave permanent content to the Maya civilization Primitive tradition has its limits; faculty of speech merely makes society possible and nothing more The invention and perfection of hieroglyphic writing and a paper on which to record it gave extension and durability to the ideas that poured from the brain of the Maya Paper aided the endless unraveling of the intricacies of the Maya calendar and helped develop Mava writing Paper, in the role of a sketch pad, doubtless played its part in the erection of their gigantic architectural monuments—monoliths which from year to year gained in masterly styles of decorative realism In time paper became one of the transmissional agents of Maya civilization and, by aiding the continuity from one epoch to another, gave substance to oral traditions The Maya accumulated books, as man had done elsewhere—in China, in Egypt, in Rome, in Greece. These books, and there were actually books, were housed and protected down through the centuries And when decadence settled on the Maya and the Transition Period (620–980 A D.) appeared in Maya history, a plateau people of Central Mexico, the Toltec, became the dominant cultural element The Toltec as the master builders of Teotihuacan, of Tula and of Cholula, are revealed as excellent craftsmen and architects even though their historicity still remains tenuous in their varied

BARK CLOTH TUNIC WORN BY A JICAQUE INDIAN OF HONDURAS
THIS CLOTH WAS BEATEN FROM THE FICUS TREE THAT YIELDED PAPER TO THE MAYA AND AZTEC

works. With the cultural advent of the Toltec the technique of paper making doubtless improved; so did ideographic writing. Although profoundly indebted to the Maya, their writing gained in directness and simplicity, so much so that by the seventh century the Toltec had, if their "history" can be credited, a "divine book," the *Teoamoxtli*, compiled at Tula in the year 660 A.D. by the astrologer Huemacin. Writing had sufficiently advanced to record in Toltec a "History of Heaven and Earth," a cosmogony, a description of the constellations, a division of time, the migrations of the Amerindian nations, a mythology and, if tradition may be regarded, a "Moral Philosophy."

Throughout all this epoch of protohistory, records in hieroglyphs were accumulated. Partly with magic, partly with techniques, like the Toltec, man everywhere sought to realize the dream of the conquest of nature. And when, like the Maya, the Toltec went into eclipse, the Aztec nation appeared on the cultural horizon between the years 1100 and 1300 A.D. The Aztec began as a nomadic people in 1168 A.D., according to their written traditions, and came in a mass migration to the lake regions of the Valley of Mexico. Here in Lake Texcoco they expanded gradually, enlarged the commanding island of the Lake and called it Tenochtitlan, the place of Tenochas. With a judicious use of rapine, bribery and statecraft, they enlarged this realm beyond the confines of the Valley of Anahuac. As the Romans took over Greek trade and culture, so did the Aztec take over the Toltec and their prerogatives. Under the Aztec much of Middle America became systematized. Trade was extended; so were the levies of tribute. All this called for records, written records. In no civilization theretofore in the Americas was there so insistent a demand for paper.

Paper was needed to record tributes, to mark the villages and cities tributary to Tenochtitlan. Paper was needed for legal documents. Paper, made into rolls thirty feet in length, was used, as by the scribes of the ancient Goths, to record methodically the accretions of their conquests. Paper took on, as it did with the Chinese, a religious and ceremonial character. Folded like a miniature screen, it was sized, made into books called *tonalamatls,* and housed at the libraries of Texcoco. And, finally, paper was used as tribute. Entered in one of the most famed of Montezuma II's tribute charts—the *Codex Mendoza*—there is recorded this highly significant item: "Twenty-four thousand reams of paper are to be brought yearly to the storehouses of the ruler of Tenochtitlan."

"Twenty-four thousand reams of paper!" Judged by any standards of a primitive civilization, such a quantity is enormous even though the Spanish word *resmas* is nothing more than an expression which fortuitously coincided with the Aztec numeral, *pilli,* or twenty. Twenty-four thousand reams," or 480,000 sheets of paper, in sum, was then to be paid annually in tribute to Montezuma II. This enormous consumption of paper by the Aztec would then seem to suggest that paper making had left the craft stage and had entered that of industry. It also brings up a question which students of history must have already asked themselves: Paper in America! Was not paper a Chinese invention?

It has been shown by Stein and Carter, and more recently by Dard Hunter, that paper *was* a Chinese invention. Hunter writes, "The Chinese eunuch Ts'ai Lun, in the year A.D. 105, proclaimed his marvelous invention of true paper—a thin felted material formed upon flat porous moulds from macerated vegetable fibre." And from China true paper penetrated both ends of the Taklamakan desert until, by the fifth century "true paper" was in general use throughout Central Asia, and within six centuries paper became general through Asia Minor and began to appear in Europe.

Paper then becomes a matter of definition, and before its dissemination can be followed, it must be agreed on as to just what paper is. Paper, in point of illustration, has two definitions—the cultural and the technical. Paper can not be wholly limited by the process of its manufacture, since paper in its cultural definition is not contained in a purely technical description, for neither the papyrus of the Egyptians nor the *amatl-paper* of the Aztecs nor the *huun-paper* of the Maya was actually "paper"; that is, paper as we now understand it.

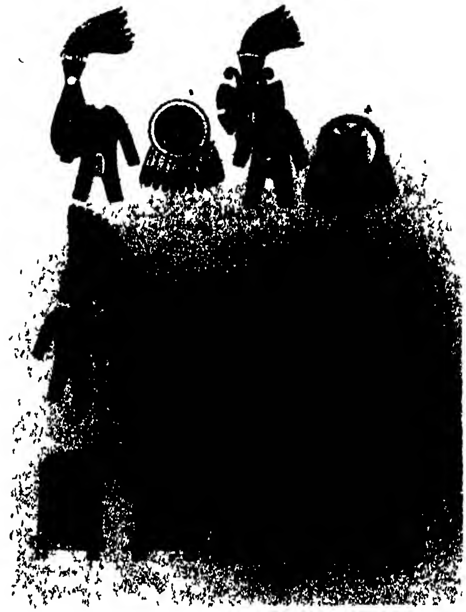
"True paper," reduced to an encyclopedic definition, is a more or less thin tissue composed of any fibrous material whose individual fibers, first separated by mechanical action (beating, pounding, etc.), are then deposited (actually felted) on a mould while suspended in water. This "true paper" was first invented by the Chinese. It was the Chinese who devised the implement—the paper making mould—which was capable of picking up the masticated fibers. This mould was so constructed as to allow the water to escape, thus leaving the interwoven fibers in an even homogenous mass which, when dried, pressed and sized, became paper. This has remained throughout the centuries the principal technique of paper making, and upon this principle the modern paper machine is founded. Not only did the Chinese invent and perfect true paper, but from the heart of China began the westward march of paper. The secret of paper manufacture was taught by Chinese paper-making prisoners while captives of the Arabs at Samarkand where they were defeated in battle in 751. This is confirmed in the annals of the T'ang Dynasty. It was the be-

ginning of the march of paper from Samarkand to Baghdad, then to Damascus, Morocco and finally to Europe via the Spanish peninsula, with the Moorish invasion in 1193.

Gradually, through the thousand years of its development, paper displaced silk, papyrus and parchment, and when it finally became "fixed" in Europe after the invention of moveable type, it supplanted all other writing substances—and upon "paper" European civilization became predicated

Yet, other civilizations reached great cultural heights without the knowledge of true paper The Egyptians and Syrians manufactured papyrus, the Mayas, *huun-paper,* and the Aztecs perfected their *amatl-paper,* so that in default of the techniques of true paper, they developed a writing surface by means of which they were able to transmit knowledge from the brain of one to another This materially affected civilization While it is not necessarily true that the quantity of paper consumed stands in direct ratio to the intellectual development of a nation (for the Inca civilization had neither paper nor writing), it is nevertheless true that man's intellectual rise has been astride the fibrous material called paper, no matter what its mode of manufacture Whether it was couched in a mould, as was the Chinese paper, or pressed into a laminated substance, as was papyrus, or beaten from the inner bark of the wild fig tree, as was the *amatl-paper* of the Aztecs, it served for writing which, once perfected, freed communication from the limitation of time-space factors

The invention of paper, in its broad sense, removed the necessity for face-to-face contact. It allowed the knowledge gained by each man to be set down in a permanent record. Compared with verbal communication, the written page increased the safety and the permanence of oral transmission, and, since copies could be made, writings could extend communications and give thought a new dimension It is from the inventions, first of writing and then of printing, that we may date the most important factors of civilization, since paper and writing caused man's experience to be projected beyond his own epoch


PAGE FROM THE CODEX MENDOZA

Thus it was that, centuries before Ts'ai Lun of Hunan Province perfected the paper mould and therewith paper, the Egyptians discovered (ca 350 B C) that by laminating strips of the stems of Cyperus papyrus, a plant cultivated in the delta of the Nile, they could fashion a smooth writing surface. Away went bones, wood and clay tablets Writing technique improved and passed from the hieroglyphic to the phonetic By learning to paste the two rough sides of the laminated paper together, they were able to make rolls of papyrus six to twelve inches wide and forty feet in length, a direct parallelism to be found

MOST ANCIENT KNOWN PAPER
CHINA, EASTERN HAN PERIOD (A D 25–220).

three thousand years later in the techniques of *huun-paper* manufactured by the Maya With papyrus and writing, an extensive literature was created, one that embraced music, astronomy, cosmogony, geography, medicine, chemistry and magic Even mathematics was reduced to writing, permitting the Egyptians to compute correctly the areas of triangles, rapeziums, and of frustums and squares of pyramids The dramas of Osiris were put into the long scrolls and even the spicy tales of Sinbad the Sailor were encompassed in a roll of papyrus forty feet long

Everywhere the Mediterranean peoples took up papyrus, the Assyrians, the Persians, and of course, those transport-agents, the Phoenicians who introduced into Greece not only the alphabet[1] but also papyrus This created the written literature of Greece.

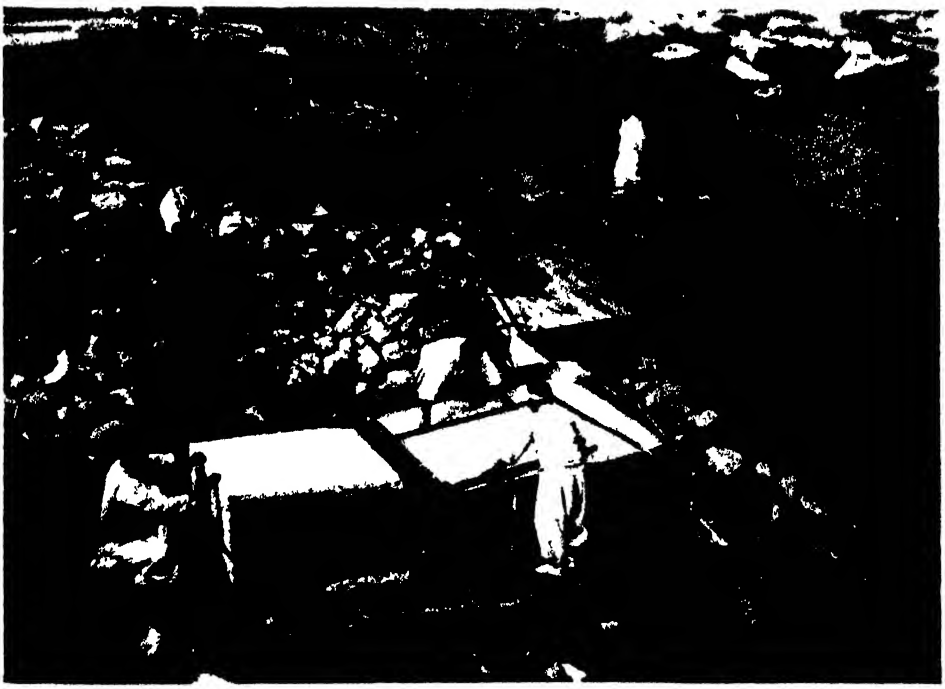
All the separate streams of knowledge in the ancient world converged on Greece, there to be filtered and purified, extended and developed The Greeks were rising to Parnassus on paper-wings

By the middle of the third century B C, the famous Alexandrian Museum had been founded by the Ptolemies Dedicated to the Muses of literature, mathematics, astronomy and medicine, they were developed and served by a library of 400,000 volumes Four hundred thousand scrolls and books! The intellectual motes were dancing in the sunbeams of the Mediterranean and making themselves visible in every direction. Papyrus, in the role of paper, had released the intellectual energies of man

Through the centuries paper and civilization continued their parallel march There were lacunae, to be sure, and cultural involutions, but whenever an epoch of anarchian violence ended, learning (now attached irrevocably to paper and writing) continued to thrust itself forward Europe, had need of paper In the great scriptoriums of the medieval abbeys, the making and copying of books were clerical vocations Yet the paper crisis in medieval Europe kept pace with the intellectual crisis, for papyrus, which for two thousand years had been a major import into Europe, abruptly ceased being available. Islam had become mistress of *mare nostrum* From that time onward the Mediterranean, natural chan-

[1] A twenty-one lettered alphabet adapted by the Phoenicians from Semetic-Egyptian hieroglyphics and introduced into Europe in 1600 B.C.

TIBETAN WOMEN DRYING PAPER ON MOULDS



FORMING A SHEET OF PAPER IN THE VILLAGE OF OMPEI, KOREA

Massachusetts Institute of Technology

INTERIOR OF A FRENCH PAPER MILL OF THE EIGHTEENTH CENTURY

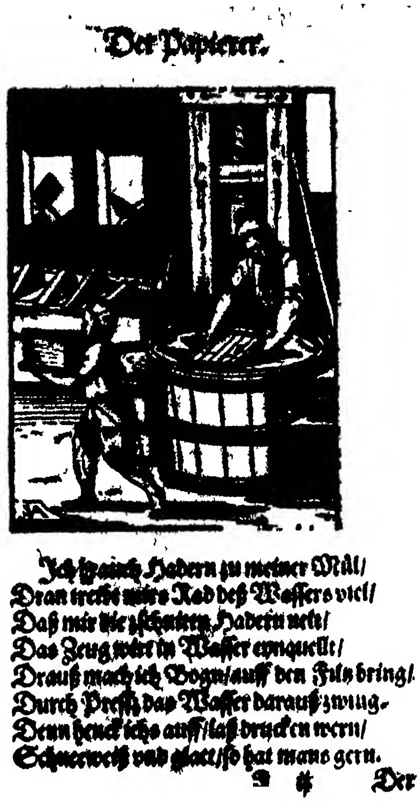
SHOWING A VATMAN, THE COUCHER, AND LAYMAN WHO SEPARATES THE SHEETS FROM THE FELTS.

nel of intercourse between Asia and Europe, became, instead, a barrier While the monk copyists scrambled for the last bits of papyrus, parchment was brought forward as a papyrus substitute

Parchment (or more properly *pergamena*) had been invented as early as the second century B C, by the Pergamene kings of Rhodes and the City of Pergamon in western Asia Minor For Alexandria, as a seat of learning, was not without a rival, and the enmity between Alexandria and Pergamon became so heated that to prevent the latter from acquiring copies of their literary treasures the Ptolemies put an embargo on the exportation of papyrus To counter this, the people of Asia Minor prepared skins and developed them into *membrum pergamentum* When the Dark Ages closed about Europe and when papyrus was again denied Europe by an expanding Moslem Empire, the monks could and did fall back on parchment.

So, while medieval Europe was papyrus-starved, the Chinese, who invented paper in the second century A D., had by now perfected its inevitable corollary, the perfected block-printed book In the memorable year 868 A D, Wang Chieh, in order to perpetuate the memory of his parents, had the "Diamond Sutra" printed on a scroll for free general distribution It was the first printed book and the invention spread like an unchecked fire throughout Asia, only to come to a halt at the Mediterranean

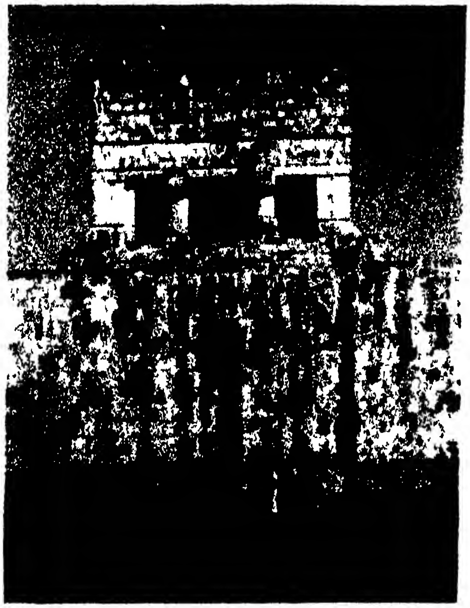
The Chinese paper makers taken captive by the Arabs in the eighth century, brought their technique to the Near East, as noted above, and in a short time "Paper of Samarkand" became so well known throughout the Asiatic dominions of the Caliphate that in the century following its introduction an Arabian chronicler was writing: "Among the specialties of Samarkand that should be mentioned . . . is *paper.* It has replaced the rolls of Egyptian papyrus and the parchment which were formerly used for writing because it is more agreeable and convenient It is found only here and in China"



EARLIEST VIEW OF A PAPER MAKER

MADE IN EUROPE FROM THE BOOK OF TRADES, GERMANY, 1568 ENGRAVING BY JOST AMMAN.

The religious wars between Islam and Christiandom prevented Europe from obtaining, for centuries, the "new papyrus," or true paper, which was being manufactured in 793 A D in exportable quantities in Baghdad, Damascus, and Bambyx The Arabs, translators of Galen, Euclid, Aristotle and Hippocrates —the Arabs, intellectual heirs of the Greeks, Master of Islam and Mistress of the Mediterranean—were now from the eighth to the twelfth centuries carrying the cultural torch; they had writing,



RUINS OF CHICHEN ITZA
HERE THE MAYA CREATED THE DRESDEN CODEX.

paper and enthusiasm. Some anonymous scholar at this time even prepared a manual called *Umdet-et-Kuttab,* which dealt not only with ink and writing, but also with the manufacture of paper from bast fibers of mulberry, flax and hemp But all this was a closed book, actually and figuratively, to Europe, closed as much by Christian opposition to all things Islamic as by the holocausts left by the Crusades The printed book, which had followed paper across the trade-routes from China to Asia Minor, stopped also at Islam The Arabs, everywhere leaders in astronomy, materia medica, mathematics and grammar, as well as being the repository of Greek learning, accepted as a firm religious axiom · "The Koran was written by hand; it must continually be written by hand. What is good enough for the Koran must also serve for any other book "

Perhaps the Arabs suspected that the printing block was cleaned by hog-bristles; more likely printing collided with tradition, and tradition won. Yet, for the moment, it meant little to the spread of learning; paper and civilization marched on in an inseparable combination, an intellectual mesh, so overlapped and blended, like the chiaroscuro of shadow and light, that the two, paper and civilization, formed, it might be said, an intellectual symbiosis Then gradually, as the Arabs expanded, they overflowed from the Mediterranean into the Spanish peninsula and so brought paper to Europe by establishing the first paper mill at Xativa, Spain, near Valencia, in 1150 A D

The Arabs were entering Europe and bringing paper, which would, in the fullness of time, help to create the renaissance So, in the same era, the Toltecs in Middle America, under the cult of Quetzalcoatl, had begun to move northward and downward from the Mexican plateaux toward the Yucatan Peninsula There the Maya, still in eclipse, had started to rebuild the City States of Uxmal, Labna, Kabah and Chichen Itza, under the inspiration of the League of Mayapan This league of cities (between 980 and 1200 A D) was characterized by the revival of architecture, the spread of paper making and the execution of ideographical books With the intrusion culture of the Toltec enveloping the Maya, the renaissance took hold among the people. Elaborate stone cities fronted with a façade of the plumed-serpent motif lifted themselves above the limestone soil of Yucatan The cultures of the highland Toltec and the lowland, jungle-locked Maya had met. Techniques had improved, so had ideographic writing The Maya began to fold their *huun-paper* into book form, and there was produced in this period (somewhere between 990 and 1100 A D) the "Dresden Codex," a sacred almanac of seventy-five pages which was set down by some anonymous astronomer-priest of Mayapan.

FIJIAN WOMEN DECORATING "TAPA," A FORM OF PAPER
BEATEN FROM THE BARK OF THE MULBERRY TREE AND USED VARIOUSLY IN THE PACIFIC ISLANDS.

Back and forth ebbed the tides of domination Eventually that which had been the exclusive property of one tribe became the common cultural currency of all Middle America. Whether the Maya, Toltec, Zapotec, Totonac or Aztec—all by the fourteenth century possessed hieroglyphic writing, all were paper makers, all had calendars, and ideographic-histories and their sacred *tonalamatls* or almanacs reduced to book form

Under the last Aztec ruler, Montezuma II, the use of paper had expanded until it became culturally linked with the production of art, writing and ritual, and part and parcel of the multifarious rituals of Aztec life Paper was used first to supply the need of artist-astronomers and for historical annals and then for the register of tributes, for map-drafts and for the delineation of land-holdings Further, *amatl-paper,* left the abstract of record and entered the sphere of ritual. Among the Aztecs paper appeared in every form of ritual In the festivals to celebrate the first month, Atlacoalo, large poles were raised (writes Padre Bernardo Sahagun) on the top of which were hung colorful strips of paper. In the fifth month, *Toxcatl,* the festival of the God, Tetzcatlipoca, there were "young girls bearing canes with paper tassels at the top," and noblemen who "wore rosettes made of paper on their foreheads and around their waists, little aprons of paper, called *amasmaxtli* " In every month dedicated to a god, paper was used in hundreds of forms. Eventually paper itself became to the Aztecs as to the Chinese, something sacred.

Paper-making villages sprang up all over Mexico These small villages, Tepoztlan, Amacoztitla, Iztacamatitlan, still exist and are still surrounded by the same wild fig trees that yielded their inner fibers from which *amatl-paper* was made. So ingrained was the

AZTEC WOMEN OF CHICONTEPEC MAKING RUSSET PAPER FROM ACACIA

art of paper making that even to-day in remote villages of Vera Cruz and Hidalgo the Indians still secretly carry on the manufacture of paper. Nothing has changed in either their choice of tree or in their use of the old instruments; all this, as the illustrations show, is a heritage of the paper world of the Aztecs.

This parallelism of paper and civilization continued then on both sides of the Atlantic Although the writing of the American Indians was still in its hieroglyphic stage and paper techniques were still primitive, the ritual-intoxicated priest-craft confined "books" to traditional moulds: Thus their progress was not continuous

Europe was, in a sense, in a somewhat similar state. Paper, which almost everywhere had been the forerunner of printing, made slow headway, for which there were several reasons First, the guild of parchment makers, who, after having nurtured parchment to meet the lack of papyrus, now opposed the introduction of a paper which would spell the doom of their craft. Secondly, there was a prejudice against paper because of its Judeo-Arabic source, but more, its spread was retarded by the lack of materials from which paper could be made Until Europeans began to wear linen underwear rather than woolen, suitable rag-waste could not be obtained from which to fashion paper Marco Polo, returned from Asia, had written about Chinese paper-making materials, yet none of the paper-making technicians had consulted him. Of Chinese paper he had written:

> . They . take the bark of a certain tree, in fact of the Mulberry tree, the leaves of which are the food of the silk worms,—what they take is a certain fine bast or skin which lies between the wood of the tree and the thick outer bark and this they make into something resembling sheets of paper.

Even the Arabs had suggested hemp, flax and mulberry; yet the techniques of paper-making were still undeveloped—so the early paper makers turned for paper to the rag waste of underwear, the easiest thing to obtain. This method of using underwear brought a snort from the parchment makers and a censure from the god-fount. Petri Venerablis, the Abbot of Cluny, while on pilgrimage to Compostela, visited a paper mill and his soul was shocked by the materials from which paper was made: "God," the disturbed Abbot is said to have written, "reads the book of Talmud in Heaven But what kind of a book? Is it the kind we have in daily use made from the skins of rams or goats, or is it from rags of old cast-off undergarments, or rushes out of Eastern swamps, and some other vile material?"

The parchment makers guild was deeply thankful for this spiritual assistance in their fight against the now encroaching paper makers. Paper thus spread slowly from Spain to Italy to France and then into Germany. But in Europe paper was everywhere the forerunner of printing. Without this strong, economical material, printing could never have made headway. Follow the path of paper and you also follow the path of printing. So on the eve of the Renaissance we find Ullman Stromer outside the walls of Nuremberg, on the river Pegnitz, establishing a paper mill and setting the paper scene for the rebirth of the spirit.

The fourteenth century was the early dawn of the modern world. It is a century that sings with the hymnal of the new life. Chaucer sang of it in England, with all its matutinal freshness; Dante gave it a richer, deeper, more human feeling in Italy. All over Europe the cathedral builders were reaching their triumph In Florence and Flanders, art was waking from its thousand-year sleep In religion the century had begun with the simplicity and beauty of the early followers; it closed with the deep moral

earnestness of Wyclif, Savonarola, Luther, Huss The renascent spirit had begun; the religion of spirit was breaking free. Already block-printing had begun in Germany, Holland and Italy Like those of the Chinese and the early chronicles of the Maya, the Toltec and the Aztec, the first books of Europe were religious Book making or printing (irrespective of where or under whom it began) has always been dependent on great manifestations of religious feeling In the whole cultural history of books, whether they be the holograph type of the Maya and the Aztec, the block-print book of the Chinese, or the books of Europe made from moveable type—the beginnings were born of the religious spirit The first book printed from moveable type was the Bible of Gutenberg. Religious books began the advance; classics continued it

As soon as the printing press showed what it could do, parchment ceased to be important Paper was ushered into the European theatre and paper mills mushroomed up everywhere in Europe Between the first printed book, in 1450, and that fateful day of 1492, three million books had left the European presses While printing and publishing did not create the Renaissance, it none the less gave impetus to it and then held its advance. It released people from their medieval nightmare and freed them from the domination of the immediate—and the local Man now became curious; he wanted knowledge. What is the earth and where does it end; what lies on the other side of the waters? The concatenation of paper, printing, curiosity and renascent man brought on extensive exploration Holograph manuscripts that had been in the possession of the few, came out into the open and in printed form Maps and charts left the archives and became popular currency *Imago Mundi*, published in 1460 (and a favorite of the man Cristóbal Colón), gave impetus to the understanding of the planets Theaticus published his trigonometrical tables. Cardan, Tartaglia, Scipio Ferrero and Stefel were improving algebra Men no longer feared the sea nor believed the earth flat Legends of austral regions across the Ocean-Sea were set in print and became the talk of men. There was a frenzied scurrying of kings and navigators, adventurers and explorers and talks of new routes to the Indies, of strange islands New discoveries were loose in the world Man read and dreamed; and one, Cristóbal Colón, more practical than all others, seized upon the dream and stole out into the unknown Ocean-Sea The isolation of the Americas came to an end The paper-worlds had met

AGASSIZ'S SCHOOL ON PENIKESE

SEVENTY YEARS AFTER

By LOUIS C. CORNISH
HARVARD, MASSACHUSETTS

LOUIS AGASSIZ triumphed. He had been leading the forlorn hope of a summer school. Suddenly, within a few days, and from unexpected sources, he received the gift of an island, a fund of $50,000, and the use of an ocean-going yacht. His dream at once was to become a reality. Marcou calls the enterprise "the most extraordinary episode of Agassiz's life."[1]

There had been talk of founding a scientific summer school. Nathaniel Southgate Shaler, Agassiz's younger colleague at Harvard, had proposed "a scientific camp meeting on Nantucket." There had been a heralding of possibilities, and a sequence leading up to the event.

In 1871 the United States Coast Survey sent a ship around Cape Horn to California, and back again, for deep-sea dredging. Agassiz was asked to make the trip, and he went. The voyage lasted from December 1871 to August 1873, and was not particularly fortunate, but it gives us an unforgetable picture. Thomas Hill, formerly president of Harvard, also went on this voyage, and he tells us how Agassiz sat upon the edge of his berth most of the night they sailed, "talking, talking, talking," while the ship fought her way out of Boston Harbor through a snowstorm into a heavy sea. Agassiz was telling of his hopes for the future of science and the methods of teaching it. No doubt among them was his plan for a summer school to teach the scientific method. He left the ship at San Francisco and returned overland. On his way he stopped for two months at Ithaca, where "a new college called Cornell" was just emerging into its distinguished career. He was promptly made a non-resident professor with the duty of giving annually a brief course of lectures, and he promptly accepted the appointment.

"In October, 1872," Mrs. Agassiz tells us,[2] "Agassiz returned to Cambridge. He found a new scheme of education on foot, one for which he himself had given the first impulse, but which some of his younger friends had carefully considered and discussed in his absence, confident that with his help it might be accomplished. The plan was to establish a summer school of natural history somewhere on the coast of Massachusetts where teachers from our schools and colleges could make their vacations serviceable by the direct study of nature." David Starr Jordan gives a more explicit account.[3] "During the previous winter," he says, "Agassiz had cast about for some means of coming into contact with American teachers of Zoology, and so exerting an influence toward better methods, for in those days science teaching in the secondary schools, and even in the colleges, was of a very inferior order, without laboratories, and for the most part lacking contact with nature herself. Up to that time nothing of the sort had anywhere existed. But he conceived the idea of meeting teachers at the seaside, away from all other influences, believing that he could thus make clear to us the necessity of going directly to nature, the

[1] Jules Marcou, *Life and Letters of Louis Agassiz*, Vol. II, p. 201.

[2] Elizabeth Cary Agassiz, *Louis Agassiz, Life and Letters*, Vol. II, p. 265.

[3] David Starr Jordan, *The Days of a Man*, Vol. I, p. 107.

fountain head—thus teaching us to recognize the truth as truth, to know that there are facts in the universe which, as Huxley says, are 'fundamentally beyond denial, and to which the tradition of a thousand years is no more than the hearsay of yesterday' "

Agassiz and his colleagues were contemplating an important advance in the methodology of education, but how to finance it was the question Always an optimist, Agassiz decided to approach the Legislature of Massachusetts, which then had the pleasant habit of making an annual visit to the Harvard Museum in the month of March We can all but see the fifty members of the General Court as they walked from the State House down Park Street to Tremont where their ten horse-cars were waiting, and then slowly proceeded to Cambridge over roads that now seem indirect, for the present bridges over the Charles River had not yet been built, nor the tunnel beneath the river even conceived The trip took about an hour, against the eight-minute run of today Walking from Harvard Square to the Museum they may have arrived wind-blown and weary Agassiz welcomed them, showed them about, and then settled them in the lecture hall Here was Agassiz's strategic chance Would they give him money for the school? He could only try So he appealed for funds sufficient to start a summer school of science somewhere by the Massachusetts seaside We do not know whether or not they were favorably impressed, although one legislator bore this testimony, "I don't know much about Agassiz's Museum, but I am not willing to stand by and see so brave a man struggle without aid " All that the legislators could do at the time was to promise to consider the whole matter So they walked back to Harvard Square, boarded their ten waiting horse-cars, and made the jogging journey back to Boston and the State House; thus they pass out of our history There was no need of their voting money for the school by the seaside. The unexpected happened.

The evening newspapers carried an account of the legislators' visit to the Museum, and of Agassiz's plea for the new summer school of science The next morning Mr H. A Anderson, a public-spirited and wealthy New Yorker, read the report in the morning newspapers and promptly presented Agassiz with fifty thousand dollars and the island of Penikese To these gifts Mr C. W Galloupe, of Boston, added the use of his ocean-going yacht, "The Sprite " All this happened within a few days, and Agassiz was free to start what Dr Jordan calls the most important work of his life And now began the first summer school in the country.

What sort of a place was his island? "Penikese," says Dr Jordan,[4] "a little forgotten speck on the ocean, about eighteen miles from New Bedford, is the outermost and least of the Elizabeth Islands which lie to the south of Buzzards Bay, off the heel of Cape Cod. It comprises some sixty acres of very rocky ground, being indeed only a huge pile of stones with intervals of soil . . It consists of two hills joined together by a narrow isthmus with a little harbor of anchorage; in June, 1873, it bore a farmhouse, a flagstaff, a barn, a willow tree by a spring, and a flock of sheep." But the island was not as negligible as we might infer "The shores yielded Agassiz untouched pools of sea life," says Robinson, "and gave him fresh research material." The complete solitude afforded was most desirable for the kind of school he was starting The waters of Buzzards Bay lay on one side of the Island and the whole Atlantic on the other Agassiz was well content.

On April 22, 1873, accompanied by members of the city government of New

[4] David Starr Jordan, *Days of a Man*, Vol. I, p. 108.

LOUIS AGASSIZ (1835–1910)

Bedford and a number of invited guests, he sailed across Buzzards Bay and, welcomed by Mr. and Mrs Anderson who had come on from New York, he took possession of his island. Shortly afterward he announced that the school would open on July 6, leaving a bare two and a half months to complete all the arrangements.

Building materials and labor were hard to transport, and proved costly, but Agassiz's enthusiasm accomplished the opening of the school on the date that had been set. A laboratory was put up, a long, narrow one-story affair A dormitory was built which contained little more than beds for thirty-five men in one division and fifteen beds for women in another The rooms were bare, showing the framework and outside boarding A new floor was laid in the old barn, the horse stalls having been torn away to make space for the kitchen. Three long tables filled the big room which was used for dining and as the lecture hall, the wide doors always left open to the sea. To these accommodations and surroundings Agassiz welcomed his fifty students selected from hundreds of applicants. Obviously they were a picked group far above the average in intelligence and purpose.

Here Agassiz was to teach them to go to nature herself for truth This was then an unfamiliar method, and the fact needs emphasis College laboratories were non-existent, and the teaching of science was from textbooks and by rote Shaler used to tell of a student who found three shells, two wholly unlike, the third with characteristics of the other two The two shells that were unlike he found duly listed in the textbook The third, somewhat resembling the other two, was not on the printed list, so he destroyed it. The list was the thing, not nature showing facts! Compare this incident with the statement of William James who some years before had accompanied Agassiz on a sixteen-week voyage up the Amazon, and knew him well. "Agassiz's influence on methods of teaching," he tells us,[5] "was prompt and decisive . . The good old way of committing abstractions to memory seems never to have received such a shock as it did at his hands He used to lock a student up in a room full of turtle shells, lobster shells, or oyster shells, without a book or word to help him, and not let him out till he had discovered all the truths which the objects contained. Some found the truths after weeks and months of lonely sorrow, others never found them Go to nature, take the facts into your own hands, look and see for yourself! These were the maxims which Agassiz preached and their effect on pedagogy was electric " This method was to be used at Penikese

"It was amusing to see Agassiz delivering his lectures," says Marcou[6] "He was surrounded not only by forty-four students, of both sexes, but by the workmen who were finishing the laboratory arrangements and erecting a new building. . . . Everyone was collecting, examining with microscopes, dissecting, or watching marine animals in aquaria improvised out of pails and buckets Agassiz lectured nearly every day, and frequently twice a day; and his passion for teaching had full play. . . (Mrs. Agassiz, note book in hand, attended every lecture) The Sprite was fully equipped, Pourtales took charge of her (Count Louis de Pourtales, an early associate and life-long friend of Agassiz), and at once began dredging, going out daily, weather permitting, with eight or ten students, and obtaining a variety of specimens which could not be procured from the shore."

Two incidents in the early days of the school give us glimpses of Agassiz's personality One shows an almost ruthless

[5] William James, *Science*, n.s. 5. 285

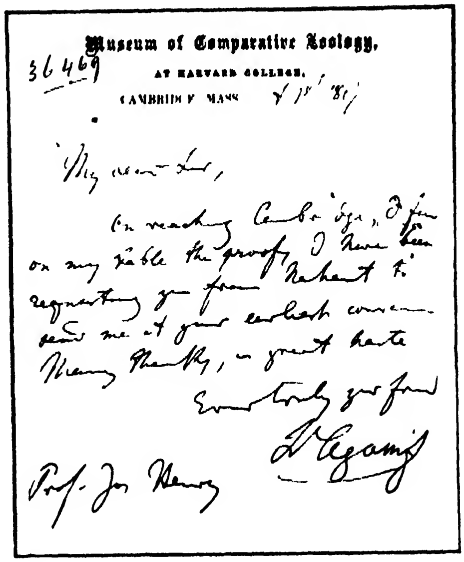
[6] Jules Marcou, *Life and Letters of Louis Agassiz*, Vol. II, p. 201.

power in eliminating hindrances, the other expresses his religion.

He had admitted women to the school Coeducation in those days was generally frowned on and often resented. Some of the men students on Penikese would have preferred to have women excluded, and they decided, as Jordan expresses it, "to teach Agassiz a lesson" They rigged up a pillow as a doll baby and late at night threw it over the blankets that hung on a rope and divided the sleeping quarters This happened in the laboratory, where everyone slept for the first few nights, the dormitory not being finished Of course, tossing the pillow caused a commotion on both sides of the curtain At breakfast the next morning Agassiz arose at his place and read the names of six men who would leave the island on the steamer at ten o'clock Pleas were made on their behalf, the incident was no more than a student's prank, and the like, but Agassiz answered that the island was not a place for students' pranks and he refused to let the men remain

Dr. Jordan tells us of the other incident [7] "Our second day upon the island," he says, "was memorable above all others Breakfast over, Agassiz arose and spoke, as only he could speak, of his purpose in calling us together The swallows flew in and out of the building in the soft June air Some of them grazed his shoulder as he dwelt with intense earnestness on the needs of the people for truer education—needs that could be met by the training and consecration of devoted teachers. This was to him no ordinary school, he said, still less a mere summer outing, but a missionary work of highest importance.

"A deep religious meaning permeated his whole discourse, for in each natural object he saw 'a thought of God.' But no reporter took down his words, and no one could call back the charm of his manner or the impressiveness of his zeal At the end he said—with a somewhat foreign phrasing—'I would not have anyone to pray for me now,' adding, when he realized our failure to grasp his meaning, that each would frame his own prayer in silence"


Museum of Comparative Zoology,
at Harvard College,
Cambridge Mass.

LETTER TO JOSEPH HENRY

Whittier immortalized the incident in his poem, *Agassiz's Prayer* It follows in much abbreviated form:

On the isle of Penikese,
Ringed about by sapphire seas,
Fanned by breezes salt and cool,
Stood the Master with his school.
Said the Master to the youth
"We have come in search of truth,
Trying with uncertain key
Door by door of mystery;
We are reaching, through His laws,
To the garment hem of Cause,
Him, the endless, unbegun,
The Unnamable, the One
Light of all our light the Source,
Life of life, and Force of force.
As with fingers of the blind,
We are groping here to find
What the hieroglyphics mean
Of the Unseen in the seen
Then the Master in his place
Bowed his head a little space.
Not for Him our violence
Storming at the gates of sense,

[7] *Ibid.*, Vol. I, p. 110.

> His the primal language, his
> The eternal silences!
> Even the careless heart was moved,
> And the doubting gave assent,
> With a gesture reverent,
> To the Master well-beloved.

The students soon fell into a pleasant routine Each morning after breakfast they tramped the island, collecting in their pails and buckets creatures new to their unaccustomed eyes from the pools by the shore and the deeper waters at the landing. Eight or ten of them went out daily on the Sprite collecting from the ocean. No doubt this was a valuable experience, but many of them found it trying when the yacht, moving slowly with her dredge, for long hours rolled heavily on the southerly swells The little island probably never had known so many visitors at any one time since it had been made by the glacier; certainly never before had it had visitors comparable in intelligence and purpose to these forty-odd young people, and to Agassiz and his companion teachers.

Our records are very sketchy, but here and there we glimpse the more personal side of the students' experiences. Writes Dr Jordan, "Lydia W. Shattuck, professor of Botany at Mount Holyoke, was a great favorite, as was also her assistant, Susan Bowen, who in 1875 became my wife."

It would be a long digression to tell what happened to the students in later life It must suffice to say that they were leaders in science. Dr Jordan was perhaps the most distinguished of them all. For the last thirty-four years of his life he was president and then chancellor of Stanford University

In the library of the University of California at Berkeley is a small folder containing newspaper clippings and a few letters about the school, at most a meager little collection. But it shows a moving touch of nostalgia "What a wonderful time we had on Penikese, what a rich experience it was, what a high spot in our lives! Never again shall we have the like!" Such is the tone of the little collection; only whispers and echoes of whispers, yes, but none the less precious testimony.

"The summer went on," says Jordan, "through a succession of joyous mornings, beautiful days, and calm nights, with the Master always present, always ready to help and encourage, and the contagious enthusiasm which surrounded him like an atmosphere never lacking A born optimist, his strength lay largely in a realization of the value of the present moment. He was a living illustration of Thoreau's aphorism that 'there is no hope for you unless the bit of sod under your feet is the sweetest in the world—in any world.' "

All too soon the weeks of high comradeship and hard work came to an end. There was no commencement, no giving of credits toward degrees All work had been done for truth's sake, and what a deep and lasting experience it had been How fortunate long ago were the students who walked with Plato in his porch! Just Plato and the porch; in retrospect one of the noted universities of the world. How fortunate were those students of yesterday who walked with Agassiz on his island, their experience was hardly more than just Agassiz and the island, an education of great and lasting worth

Agassiz was not to return. He died in December Whittier's poem continues,

> In the lap of sheltering seas
> Rests the isle of Penikese;
> But the lord of the domain
> Comes not to his own again
> Where the eyes that follow fail,
> On a vaster sea his sail
> Drifts beyond our beck and hail.

The next summer there was a second and last session of The Anderson School of Natural History. Students came and worked hard under able teachers, but without the Master it was not the same school A sense of loss and loneliness

prevailed. One evening they all gathered in the old barn and those who had been there before talked of Agassiz. One of them said, "He was the best friend that ever student had." They wrote on strips of cloth and put on the walls mottoes taken from his talks. Here are a few of them:

Study nature, not books.
Be not afraid to say, "I do not know."
Strive to interpret what really exists.
A laboratory is a sanctuary which nothing profane should enter.

These phrases were left on the walls of the empty building for fifteen years and were then carried by Eigenmann, a student of Jordan's,[8] to the Marine Station at Woods Hole, which in a way is a successor to Agassiz's school.

No more money was forthcoming. Without Plato, what would his porch have amounted to? Despite an able faculty at its second session, it may be questioned whether the school without Agassiz could have continued even had the money been given. With all credit to the others, the island without the Master would have been very different from what it had been with him there.

What followed the school on Penikese, raised for a brief time to scientific fame, and then dropped into a sea of solitude? The school buildings never were used again. Some twenty years after the closing they were struck by lightning and burned to the ground. In 1905 the Commonwealth of Massachusetts bought the island for $25,000 for the isolation and care of lepers. Up to 1921 some twenty unfortunates were received, all from foreign parts, Greece, the Cape Verde Island, and China among other places, except two who were American soldiers. In that year they all were transferred to the national leprosarium at Carville, Louisiana, where all lepers in the United States are cared for by our national government. It is to be noted that during the sixteen years when the island was the place of detention for lepers, medical scientists followed the strictly scientific methods taught by Agassiz in their effort to find a cure for leprosy. Massachusetts still owns Penikese and of recent years has made it a bird sanctuary.

Says Whittier, "In the lap of sheltering seas rests the isle of Penikese." With appreciation for the necessities of poetic license, those who know the waters around Buzzards Bay have wondered a little at this line. "What happened to Penikese in the hurricane of 1937?" I asked a local authority. He answered, "One of the hills was washed away."

Looking back over the seventy intervening years we realize that Agassiz started all the summer schools that ever since have flourished independently and in connection with the colleges in all parts of the country. Now it seems likely that for the most part they will become the summer sessions of the universities, a worthy culmination for a notable movement in American education. We realize also that the scientific method taught by Agassiz is now followed in all schools. In his struggle against ignorance and prejudiced conservatism Agassiz has triumphed.

High on the façade of Stanford University Dr. Jordan placed the statue of Louis Agassiz. He stands facing the east, where the dawn breaks over the foothills.

[8] Jordan, *Days of a Man*, Vol. I, p. 118.

ANOMALIES IN COLOR VISION

By Dr. ELSIE MURRAY

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HUNDREDS of young men eager to play their part in the great drama of the sea and air have struck unexpected hurdles in the office of the medical examiner, emerging with the disqualifying verdict, "color-blind" In vain they protest that they can see colors as well as the next one, that there are no gaps in their rainbows Many of the rejects affirm further that they have no difficulty in distinguishing red from green, are never bothered by traffic lights Obviously, they assert, the tests are unfair.

No, they are not unfair, as such things go, in the best of *possible* worlds Severe they are, however; and indeed at the present hour they need to be. Misreading of a signal at dusk, in the rain or at a distance, in the face of the enemy, might mean the crash of a bomber, the death of a whole ship's crew, the annihilation of a battalion.

Today's favorite screening test for color deviates is composed of small multicolored charts, such as those long ago devised by Stilling and Ishihara. Each chart contains one or more digits or letters formed of tiny colored dots and disks, on a differently pigmented ground, discernible or not according to the color sensitivity of the observer. These digit-mosaic charts, Franco-German in origin, with their later Japanese, Russian and French variants, are known to the specialist as *pseudo-isochromatic*. Digit and ground are made up of carefully selected "confusion colors," producing on the anomalous eye the illusion of identity, and causing the digit or letter to disappear in the ground.

Such tests utilize the fact that so-called "color-blindness" is not blindness to color, but loss or weakening of certain sensory responses, automatically reducing the number of discernible color differences. Red and green are most commonly affected. When these drop out—together, as they usually do—the differences between digit and ground, readily perceived by the color-capable, are obliterated. The entire field may turn to grey; or, in the case of a violet digit on a blue ground, the whole array of dots and disks may appear in tones of blue, through fading of the red component of the violet. Either change renders the digit invisible or illegible

In their present form, the charts admittedly are not analytic. They are keyed to spot *average anomaly,* plus one variant only: the rare form due to shortening of the red end of the spectrum (scoterythrous vision, sometimes ambiguously termed protanopic). They are not designed to diagnose or classify the vast number of deviations from the typical, many perhaps semi-pathological, known as *borderline cases*. They do not even clearly segregate color-blind from color-weak Many clinicians ignore this, however, accepting the set of charts unthinkingly, as the average man does his radio, or a Solomon Islander might a motor, with no concern as to the inner principles of its operation.

Unquestionably, the tests now in vogue are more severe than the old wool-sorting ones of Holmgren, evolved long ago for the selection of railroad engineers. The latter, utilizing wool skeins instead of a printed mosaic, offer larger masses of solid color of high chroma, over which the eye can travel freely. Matching or sorting these at a lesser distance, the examinee with a central scotoma (color-blind area), or a retina pock-marked all over with scotomata (minute insensitive points), or even a high degree of red-

green weakness can make a passing score. The digit-mosaic, or "vanishing pattern," test, on the other hand, though far from perfect, if administered by an expert, under standardized conditions, with vision corrected for refractive errors and deception barred, does the job more efficiently than any wool test—Holmgren, Jennings, Nela. Its rejects actually are dangerous cases, with color vision unequal to today's exacting military tasks. In all but highly favorable and stereotyped situations, they carry on under a definite handicap. In emergencies they constitute a definite liability for comrades and commander.

Why, then, is it that the diagnosis of disability comes as a shock to the examinee, who was not born yesterday? Why are protests so common? There are many reasons, and it is high time that science undertook to clarify them for the general public.

First of all, one must admit that protest is in a measure justifiable. The term *color-blind* is a misnomer. The fraction of cases who see the world in tones of grey—a Turner or Matisse, as it were, in a black-and-white or half-tone cut—is negligible, and semipathological. The American vogue for streamlined, abbreviated phrases works against the substitution of "color anomalous"—six-syllabled instead of three, and evoking vague visions of Harlem, of epidermal as well as retinal deviation. A concise color vision variant (C.V.V.) would fit the facts more nearly, in the opinion of the writer.

The older term, even when qualified by *partial* or *red-green*, as already hinted, is misleading. The average reject is not blind to color. The photo-receptors in his retina respond as a rule to all color stimuli, including those linked with the very sense qualities lacking in anomalous vision, red and green. He has merely reverted, as it were, to a simpler type of eye, sensitive to all light frequencies, but reporting them in terms of a single pair of qualities, blue and yellow. Science terms this, not blindness, but a *reduction system*. (Occasional shortening of either end of the spectrum does occur, but whether due to insensitivity or to absorption of light waves in transit to the receptors is a point unsettled.)

A second source of grievance centers in the failure of current pseudo-isochromatic charts to segregate degrees of disability, *color blindness* from *color weakness*. All who fail on three or more charts are usually thrown out together. As a matter of fact, to this day no one knows whether or not all gradations of color sensitivity from normal to red-green blindness and on to achromatopsia (loss of all color qualities) occur. Test results claiming to settle the point run back over a hundred years; but doubt arises as to whether the scatter is due to technique and method or to individual differences in color thresholds.

Some of the loudest protestants against the army and navy test diagnosis fall undoubtedly in this intermediate class, termed by Von Kries "anomalous trichromates" (with several other syllables agglutinatively added). Their red is probably a reddish orange, their green bluish or greyish, their color fields restricted. At dusk, in rain or fog, their weakened red-green color pair is likely to fail them. They are subject to rapid color fatigue, and are likely to see vivid complementary color halos amounting to illusion on the neutral background of small color fields. While they can "get by" in the majority of everyday situations, can even handle technical color work with certain precautions, they are virtually color blind in slightly unfavorable or unusual circumstances, and consequently are possible sources of danger. The writer has yet to contact an experienced military officer who would care to risk them in his entourage.

As for the red-green blind who lacks entirely this pair of sense responses, his obstinate denial of disability stems from

various sources. Unwillingness to admit defeat is universal, *vide* the vast literature of inferiority complexes. Each of us, moreover, is confined in his own sense world. The anomalous-visioned has no eyes but his own to see with, no standards but his own to judge by, no more notion of the sense quality he lacks than the layman has of the fourth dimension. As the traveller in Arabia acquires perforce a few Arabic phrases, he experiments with his color-capable neighbor's vocabulary, and often achieves a modest success. Mistaking brightness and vividness gradations in the yellow region of his spectrum for greens and reds, he obstinately insists that his repertoire of colors is as complete as his neighbor's.

This fixed obsession of many color-blinds and color-weaks that their buffs and tans and browns are unique hues, identical with the greens and reds of everyday speech, finds an analogue in the behavior of certain normals. Untrained in color terminology, ignorant of the permutations through which a single hue may pass by darkening and dulling, when asked to sort fifty color samples by hue the color-capable not infrequently refuses to throw buffs and tans and browns in with yellows or oranges. These country cousins of the more gorgeous hues, he insists, are something apart, unique, deserving of two extra piles or compartments. The existence of specific color names, such as tan and brown, is cited in evidence. Only careful study of the constant-hue pages of the "Munsell Manual of Color" will convince him otherwise.

Use of his neighbor's color terms correctly in perhaps fifty per cent. of cases often camouflages color disability in the deviate's social circle. Early family incidents, it is true, may break through this verbal guard, especially in country districts. The lad who can not see the proverbial cherries on the tree a rod or so away, or detect the pink flush on the cheek of a ripening peach or apple, has it driven home that his vision is unique, and learns to his sorrow that no oculist can better it. The hunter who fails to sight the red squirrel or partridge in the autumn woods, or mistakes the red coat of a comrade for the tawny one of a buck, learns his lesson also.

A younger sister's jibes at eccentric color combinations—a red sweater worn with purple socks, a violet necktie with a bright blue shirt—are also effective in opening the eyes if not in improving the taste or vision of their target. Yet often these early warnings slide off like the proverbial water from a duck's back, leaving their recipient placid in the belief that colors and color names are purely feminine preoccupations, which any male could master if he put his mind to it. In the 30's and 40's, to be sure, when colored inks began to invade the masculine precincts of printing and advertising, neon lights to transform quiet thoroughfares into garish midways, and even bathrooms and kitchens put a strain on the color eye of the plumber, the male and especially the color-blind began to be color-conscious.

Few college students now get past the medical office without some intimation of their status. Sceptics are apt to be tripped later in the psychology classroom as they match yellow skeins with pink to the delight of their color-capable fellows. In order to drive the point home, fraternity brothers have been known to consign expensive but gaudy outfits to the lock-box. Many still persist, however, in referring their idiosyncrasies to taste and interest rather than deficient sense equipment. Ability to read recent faultily printed and valueless pirated editions of the digit test helps confirm them in this attitude; as does also the fact that the reds and greens most damaged in deficiency are not the typical reds and greens of flame and foliage, but a certain crimson and verdigris of a bluish cast. (Of this more later.)

At this point the sceptical will propound a riddle. If no notion of the visual world of the normal-eyed is pos-

sible to the color deviate, how can science hope conversely to penetrate the half-world of the latter? Nature has obligingly furnished the normal eye with certain cues, with the aid of which the color specialist can construct the color world of his undervisioned brother, much as the paleontologist evolves a mastodon from a molar One such cue is furnished by the color-changes hues undergo when passing into the marginal fields of vision. For the normal eye is completely color-capable only at the center. Between this and the outer totally color-blind zone is a middle region of partial or red-green blindness. Test this by drawing small bits of colored paper (red or green or orange) away from a central point of fixation and you discover that when red and green fade out *blue and yellow* take over.

Combining this cue from indirect vision with the testimony of monocular color-blinds, we gather that where the normal sees green in the spectrum the red-green blind sees tan or fawn or sand —a dulled yellow. "Sand" becomes stand-in for green, appropriates its name, gets accepted as a unique hue—the color of grass and foliage. The verbal tag "red" attaches itself in like fashion to the golden brown that dominates the long-wave end of the color deviate's spectrum. Through association, these terms may then be used correctly in a surprising number of cases. Often, however, a mere passing shadow on a colored surface, or a stray sunbeam, is sufficient to alter the judgment of the color deficient from green to red or vice versa. Certain tones of yellowish red and yellowish green are, indeed, indistinguishable (confusion colors). Hence combinations of these are avoided in up-to-date traffic light systems, a *bluish* green doing duty as a "Go" signal with a scarlet or yellowish red for "STOP"

This translation of the visual world of the partially color-blind into tones of blue and yellow was early described by discerning members of the group. Rare and interesting cases where one eye was normal, the other color-deficient, or where color disability was acquired at maturity or later, confirm the earlier accounts. Laboratory matches of one portion of the spectrum against another complete the story. The accumulated evidence, admirably summarized in 1925 by Drs Mary Collins and James Drever of the University of Edinburgh laboratory, shows conclusively that the majority of cases stigmatized as "color blind" by examiners are *not blind to color stimuli.*

Though the color deviate's retina responds to about the same range of light stimuli as the normal's, i e., wavelengths of 390 to 780 millimicrons, the number of colors sensed as different is reduced. Of the 150 hues seen in the vividest band of colors by picked observers—of the blues, indigos and violets, the leaf-greens, emeralds and peacocks, the golden and greenish yellows, the scarlets, oranges and crimsons—the red-green-blind retina discriminates surely just two, the blue and yellow above mentioned. (So the famous chemist Dalton long ago assured us.) Hence the color palette of the *dichromate* (so science dubs the typical undervisioned) is tremendously restricted Instead of the millions of permutations and commutations of the 150 hues with light and shade, he has only thousands or possibly hundreds in his repertoire of color.

To one who has never been a millionaire an income running into four places is not despicable. But had the color world of *Homo sapiens* never developed beyond that of the dichromate, the voluminous dictionaries of color and color terms (Maertz and Paul's and Munsell's) would never have been evolved. Nor would an elaborate color solid formed of two pyramids base to base on a central black-white axis, every fragment of its surface under successive strippings unlike every other, be needed to figure compactly your color world and mine.

A mere plane section of this elaborate figure suffices to display the diminished color capital of the dichromate. For the rare case of complete color-blindness, the black-white axis (with grey intermediates) alone is needed. The visual world of this unfortunate is to ours as an engraving of a landscape or a portrait is to a Raphael or Childe Hassam original

Brief reference to physiological theory may illumine further the enigma of color blindness Laboratory techniques demonstrate a complex and variegated apparatus of rods and cones and nerve structures in the minute microscopic tissues of the retina (the latest word on which is offered by Polyak's "The Retina"). Parsimonious science, however, needing every pinpoint of the retinal mosaic for space perception, refuses to allocate separate elements to each of the numerous hues of the color pyramid. Instead, she factors her continuum of 150 hues into four primaries, to each of which is allotted proprietory rights in certain nervous structures; combinations of these four provide intermediates.

Choice of the four primaries is dictated by certain observations. The position of the grey bands in the low-intensity spectrum of the color blind—near 500 mμ (a faintly bluish green), and toward the long-wave end (a slightly-bluish red)—affords the first cue. The stability of certain hues under altered light intensity offers another; and the identity of the four thus chalked up with those that in the marginal fields either do not alter (blue and yellow), or that pass without change into grey, clinches the matter. Inductive science therefore picks as her four basic hues crimson and verdigris, blue (slightly purplish) and golden yellow.

These four, thus inductively determined, turn out to be two sets of true complementaries, linked in pairs by still other visual phenomena, negative after-images, contrast halos, and the fact that they neutralize each other on the color-wheel. The pairs so linked are blue and yellow, crimson and verdigris. In ordinary red-green blindness, the last-named pair is the one affected—the one most likely to lose all color tone with low illuminations. Various interesting explanations of this linkage, chemical, physical and histological, are available.

The fact that the two primaries thus singled out by the finger of nature as less stable are not the typical scarlet of the poppy or the yellowish green of grass, which perhaps come first to mind with the words *red* and *green,* adds to the sum of grievances of the unfortunate red-green blind. For the reds and greens of everyday speech, as already mentioned, are effective stimuli for the yellow sense apparatus, appearing as browns and tans in severe cases, as oranges and olives in mild cases (the merely color-weak). In like fashion, very bluish crimsons and greens may be seen as dull blues through the action of the reflected light waves on the blue sense-apparatus.

One hopeful corollary of this is that the world of the color blind is not all dun and drab. He is usually quite blue-yellow capable [1] Bluebells and daffodils, wild asters and goldenrod, blue eyes and blond locks, chicory in the ripe wheat, lose no whit of their appeal The glory of a Titian-hued coiffure is, however, wasted on him A color-deficient husband is reported to have described the hair of his red-headed wife as "lacking in pigment" Lipstick preparations may call out similar verdicts, though a number are easily confusable with grass-greens

At this point we may profitably follow the lead of the notable nineteenth century Dutch ophthalmologist, Donders, who had recourse to evolutionary theory. In many of the lower animal species the

[1] In a rare form of color deficiency, blue-yellow blindness, the residual hues are red and green.

discrimination of colors—of greens from blues, reds from browns or greys of equivalent brightness—is strictly limited. Various orders, of which the domestic horse, dog and cat are members, display, in short, the equivalents of partial or total color-blindness. Hence Donders and his successors attributed to the earliest type of eye black-white-grey perceptions only. Blue-yellow apparatus for daylight vision, linked with the retinal cones, followed next, perhaps in a primitive lemur, perhaps in an early primate. These two hues, blue and yellow, shared the spectrum at the start, one taking over the short, the other the long wavelengths, "licking the platter clean" between them Their cones drove the rods, organs of black-white night vision, out toward the edge of the retina (hence to see a faint star you must view it out of the corner of your eye). The crimson-verdigris (or red-green) sensory pair came on the ground late, insecure interlopers, hunting a place in the sun, encroaching on their predecessors without displacing them Never gaining entrée to more than a restricted central field, never setting up exclusive claim to any wavelength of light, they are the first to go down under pressure, e.g., in congenital or acquired color-blindness.

This evolutionary view, with slight distortions, was popularized by the late Ladd-Franklin, who attempted also a *rapprochement* between the color theories of physiologist and physicist For, unfortunately, the formal mathematical approach of the latter, his color-mixture formulas and "as ifs," sometimes mistaken for fact in the field of color perception, have so far operated to paralyze rather than promote research in the field of color-blindness. Much of the present backwardness in the designing of tests must indeed be laid at the door of the physicist; for in the last analysis he is the apparatus builder on whom all science is more or less dependent; and unfortunately he is more apt in designing optical apparatus of his own, *e.g.*, the trichromatic colorimeter, than in studying Nature's models, in animal and human

Since the dawn of history, it appears, the number three has intrigued philosophers, theologians and some physicists, exerting a benumbing spell on the reflective faculties. Triangles, trefoil, trinities of all sorts have found little to oppose their fuhrership. Obviously, the triangle is simpler than the square, and tables of three coefficients not only more economical to print, but easier to prepare and manipulate than those of four or more Apparatus with three variants only is likewise simpler to handle.

And did not Aristotle himself remark that all things have a beginning, a middle and an end? Why not the spectrum? Even the wise Helmholtz was beguiled for a season into fitting the facts of color vision and color-blindness to a three-fold Procrustean frame, taking red, green and violet as his sole primaries. Some of his too zealous followers perpetuated the triple scheme he presently rejected in the terms *protanopia, deuteranopia* and *tritanopia* Protanopia is by definition lack of the *first* primary, red (blindness to long wavelengths of light); deuteranopia, blindness to the *second,* green; tritanopia, lack of the *third* sense quality, violet (blindness to short wavelengths) It matters little to the Helmholtz enthusiast that the three types as defined are non-existent (a fact the old scientist himself appears to have discovered). Modern disciples go blithely on their way, evolving yellow preposterously from red and green, white from a fusion of red, green and violet—elaborating and complicating hypotheses in the vain effort to herd the vagaries of color vision and the known facts of color-blindness under the aegis of the sacred trinity.

Near matches acceptable to commerce (though not to observational science) are

obtainable by triple primary methods, tables and apparatus, which thus fulfill a definite function in maintaining standards in dyes, drugs and agriculture. Evolution of a spectrophotometer which analyzes light reflected from a given sample into a continuous curve, doing justice to intermediate wavelengths, promises better than the old tri-stimulus colorimeters, with their "dominant wavelength" telling too little of the actual look to the eye of a sample under average daylight.

Unhappily, however, the mathematical "as ifs" and hypothetical types of disability of the physicist constitute definite stumbling-blocks in the way of penetrating the plight of the color-anomalous. Nature *might* have made an eye on the triplex pattern, indeed she may have in the case of birds and reptiles, with three oil-drop color filters. But she appears to have discarded this design in the case of man (so we interpret the latest findings of Gordon Walls in "Visual Mechanisms" and "The Vertebrate Eye"). As long ago as 1932, moreover, the eminent authority on physical optics, R. A. Houstoun, of the University of Glasgow, in his "Vision and Color Vision" declared the Young-Helmholtz theory "mathematically untenable," "a violation of common sense," and a failure in classifying cases of color blindness. Even the editors of the third edition of the "Physiologische Optik" thought best to discard or alter Young's original schema of defect Yet in the backwaters of academic classrooms it still lifts its head, to the confusion of the student For regrettably no explanation of the visual phenomena of color-blindness at all serviceable to the layman has yet evolved from trichomatic theory.

Turning from physics to genetics, we find a new set of riddles in the incidence of color anomaly in the population. Partial or red-green blindness (the ordinary type, attended in some cases by darkening of the red end of the spectrum) tends to run in families. It may affect two or more brothers, rarely a sister, eugenists tell us. Search into pedigrees often reveals a grandfather, usually on the maternal side, similarly afflicted. The charts in Julia Bell's "Anomalies and Diseases of the Eye" (in the *Treasury of Human Inheritance* for 1933) show that partial color disability follows the Mendelian pattern fairly closely. Thomas Hunt Morgan, the geneticist, classes it with haemophilia as a sex-linked or recessive trait, associated with absence of an element in a chromosome.[2] A color-blind man's daughter, though color-normal herself, may transmit disability to her sons. To prove this point, many pedigrees have been compiled; but the facts do not always fit the theory. It appears that red-green blindness may be incomplete (as already intimated); that there are half-way cases, retaining some red and green sensation under adequate stimulation. The woman carrier of the defect may prove to be such a case when analytically tested.

Both types, color-blindness and color-weakness, may be either congenital, or acquired through the use of drugs, infection or pathological nerve conditions. For more than a hundred years science has worried over the deviations from type, the borderline cases. Whether they are due to retinal deficiency, or to pigments in other of the eye tissues that block the passage of certain rays, such as yellowish green in the lens or cornea, is a moot question. Adequate tests to assay these deviations have yet to be devised—but a friendly warning is in order. It is not worth while arguing with anyone over the precise color of a gown or a cravat. The chances are two to one or better that each pair of eyes

[2] Merely recessive, apparently, in total color blindness (achromatopsia) and its borderline forms, which affect women almost as often as men.

sees them differently. Acquired cases, due to the excessive use of alcohol or tobacco, or to systemic toxins, are probably also more frequent than was formerly supposed.

Of the handicap of color disability, complete or incomplete, in military operations on sea or land or in the air, there can obviously be little question. Not only is confusion likely to arise in critical moments, in mist or smoke or fog, obscuring signals, veiling enemy approach or camouflage, but the color-sensitive zones of the eye are narrowed, and color signals in the marginal field may be overlooked. Perception of perspective, judgment of distance and contour is likewise subtly disabled by lack of color-toned shadows. Experience shows that color-blind aviation students are not only handicapped in the choice of a landing (ploughed field and forest being similarly toned); they are apt to fumble in any visually regulated setting down of a plane.

Granted a handicap affecting four to ten per cent. of the male population, speculation as to remedial measures at once arises. Myopia can be corrected with lenses, heterophoria with exercises. What of color-blindness or weakness? Publicity of late has centered on the discovery by Wald and others of vitamin A in the chemical cycle of rhodopsin or visual purple (the photo-sensitive substance linked with night vision) Heavy dosage with vitamin preparations, or with liver or codliver oil, has been experimentally studied, and in many cases lowered thresholds in the retinal rods (the receptors active in faint vision) have resulted.

Somewhat rash inference that color thresholds in the cones, the organs of color vision, are lowered also (the first test case was one of alcoholic cirrhosis of the liver) has led would-be benefactors or notoriety seekers to experiment with high dosage of men who were failing in army color-tests. The results so far are ambiguous with no guarantee of the permanence of improvement. The sensory apparatus for night vision and for daylight or color vision has long been recognized as twofold. No sensitizing or sensitive substance in the cones linked with color vision, as the visual purple of the rods is to light perception, has yet been isolated in man. The chance that it is a carotenoid with vitamin A in its cycle is relatively slight, though some evidence points toward a visual violet. Acquired, or pathological, cases of color-weakness, it is true, might be kept at higher levels of efficiency by heavy vitamin dosage. But until reserves run low, what use has Uncle Sam for a submarine captain or a commando dependent on a pocketful of pellets? Meanwhile nutritionists and white-ribboners are capitalizing on the situation. If color vision can not be improved, they argue, it should at least be guarded from deterioration

A certain measure of consolation may be meted out to the reject whose hopes of cure are dissipated. His case is not unique One out of every ten or so of his fellows is in the same predicament. He has, moreover, distinguished company, past and present. Color vision anomaly was first called to the attention of science a century and a half ago by a famous chemist, Dalton. (He was a Quaker and is said to have scandalized the congregation by wearing scarlet hose to meetings) Today, in every college faculty there are several cases, usually in mathematics—a safely neutral subject. Engineers, architects and metal workers account for additional per cents

Those who have chosen a vocation incompatible with defective color vision, and now discover themselves in the wrong pew are less consolable: the florist, the dyer, the drygoodsman, the color photographer, the make-up artist, the theatrical producer—or the plumber. Chemist or physician can often be fitted

by expert oculists with polarizing lenses or colored filters which, though they can not restore the missing hue to vision, may by bleaching or darkening enable the wearer to detect its presence in certain cases.[3] Novelists may go blithely on their way, using color terms in conventional fashion—witness Ben Ames Williams and his annual output. Artists can get along with labelled tubes, though sudden discovery of the handicap may precipitate a nervous breakdown. It is, by the way, a favorite theory of the writer that the recent vogue for daring color combinations was launched unwittingly by some color-blind artist, with never a notion that his visual world was unique, or his canvas other than two-hued. For no color discords exist for the dichromate—his eye paints everything in harmonizing complementaries—if our postulates are not all awry.

With the progress of science, other perspectives and vocations may open up. Many interesting problems, the solution of which would benefit the entire fraternity of the undervisioned, are yet untouched. Among the anomalies there may well be eyes supersensitive (as well as subsensitive) to certain colors, the fitting allocation of whom in the world of tomorrow awaits discovery. Racial differences harking far back in evolutionary history may come to light when appropriate tests are adopted. Research biologists, George Wald of the Harvard laboratories among them, tell us the two types of retinal carotenoids associated with vision in deep-sea and fresh-water fishes persist long after a species has forsaken its ancestral environment, except for spawning (*vide* the eel and salmon). It is possible that some human beings inherit the equivalent rhodopsin, some the porphyropsin of these lower vertebrates, with corresponding shifts in sensitivity to light and color. Among the borderline cases there may be atavistic eyes, eyes strictly nocturnal and eyes diurnal, as distinct from the twenty-four-hour duplex mechanism most of us inherit. From the mass of rejects, cases may be sifted out uniquely fitted for submarine, destroyer or airplane service. The red-weak (protanope of the physicist) may be jungle-eyed, best suited for twilight vision; the blue-weak, eagle-eyed, best adapted for desert action.

Our present tests for the most part are not diagnostic, merely separating out safe from unsafe relative to a conventional situation. Some evidence is already available, however, to show that Mediterranean, desert and atoll-island people are blue-weak, with diurnal vision dominant, an eye protected from ultraviolet rays by yellow-pigmented tissues. In like fashion, red-weakness may stem from forest and jungle races, or people of the foggy northlands, with eyes adapted to twilight vision.

Instead of raging against fate, or the Japanese and German tests which are still the main stock-in-trade of the examiners, one wonders why no disappointed reject has thought to organize his fellows. Anecdote and jest at discordant-hued cravat and hose, at nonchalant slipping past urban red lights dimmed to slim four-armed crosses, lose their sting when all are equally exposed to the shafts of wit A mass of interesting data could be assembled, the matter of heredity reconnoitered, the feasibility of prenatal treatments laid before the medical profession, cases of acquired deficiency explored. Pressure might even be brought to bear upon examiners to write "color-anomalous" rather than "color-blind" across vocational score-cards.

We suggest that, when the war is over and our boys have emerged from the jungles and the deserts and come up from the bottom of the sea and when the problems of the Axis-ridden peoples of

[3] Practise with colors does little to speed up the slow color reactions of the color-weak.

Europe, Asia and the islands of the Pacific have been temporarily adjusted, our scientists get together on the plight of this tenth of our own male population. All-American tests need to be devised, compulsory in the lower grades of the public schools and at graduation. The examined should be provided not with a blanket verdict "color-blind" nor even with a single color quotient, but with a *color profile,* showing at a glance daylight ability relative to the average in half a dozen hues; starlight and total blackout sensitivity also.

Meanwhile those of us who are color-capable may well devote an occasional moment to mentally recasting the world about us—aswarm with traffic lights and neon signs, gay with war-motivated scarlet costumes, aglow with florists' windows and tropical flowers, or lit up with autumn foliage—into the two-hue system of the dichromate, blues and yellows—a partial color dim-out.

THE CALLAO PAINTER

By Dr. ELIOT G. MEARS

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At times, the inhabitants of Lima's seaport remark, in their native Spanish, that "the seawater is sick, for it stinks" Simultaneously, they experience distressing headaches, the silver in their houses tarnishes, and the old paint on their fishing craft inshore becomes discolored. This marine phenomenon, which has an established history, has received scant notice in scientific journals. Locally it is known as "aguaje," less frequently as "agua enferma." Leading Spanish dictionaries fail to define these expressions according to their local usage. The name most used internationally may be said to be the "Callao Painter," so called after its marked distinction in blackening white and other light-colored boats in the Bay of Callao (lat. 12° S).

The manifestations are well known and fairly regular in occurrence. At undetermined intervals, but frequently during the Southern Hemisphere's summer and early fall, the Peruvian seacoast from approximately Paita (5° 05′ S) to Pisco (13° 43′ S) experiences a marked turbidity of the sea accompanied by the strong emission of hydrogen sulphide. Enormous quantities of dead plankton float about and line the shore. Guano birds die by the thousands These striking transformations are normally associated with the invasion of warm water from the Equator into the cold Humboldt or Peru Coastal Current. Sudden and marked sea and land temperature changes are conspicuous; to many persons, these meteorological variations are a sufficient explanation Yet the underlying reasons for the "Callao Painter" are still undetermined owing to the fragmentary physical and biological oceanographic data. The causes are likely to be found in more than one field of investigation carried on in this unique Pacific South American region.

According to tradition, submarine volcanic action has been alleged to be the real cause. Doubtless the unsettled mass formations, including frequent earthquakes, did provide a ready answer. But there has come to light no worthwhile evidence, based upon scientific investigation, why the oceanic area associated with the Humboldt or Peru Coastal Current should account for such local disturbances. The presence of a volcanic rim around the Pacific does not help us materially towards a solution. The "aguaje" is conspicuous in protected

bays where the local eddies and currents appear to accentuate the situation. We are justified, however, in discarding the early hypothesis.

A number of other explanations have been offered. They merit notation, even though they can not be discussed at length. For example, it is well known that many forms of cool water life can not be maintained in the presence of warm water. For, when warm currents appear in such an area, maladies occur and deaths ensue in proportion to the contrasting temperature of the trespassing current or eddy with that of the Humboldt Current. This fact might seem adequate here; but if so, how can we account for the proven incidence of illness, in the year 1925, before the invasion of the warm current? That is one of the mysteries which requires further study.

Again, why should warm oceanic water, which ordinarily avoids the cold Peruvian current, measuring as it does from 2500 to 3000 miles long and from 100 to 250 miles wide, occasionally or periodically flow across or replace it? Several hypotheses have been advanced, notably by E. W. Barlow, of the British Meteorological Office, who, in summarizing the observations in 1939 of the Volunteer Merchant Fleet of 923 ships, found that even the strongest currents have reverse sets. For instance, the steadiest stream in the South Pacific, the South Equatorial Current, has many eastward sets during the southern summer when it is weakest, and at any time in the year such a current may be met occasionally.

The Peru Coastal or Humboldt Current receives its most severe reverse sets in summer also, but it may have inshore or southward moving currents in winter, when it is at its greatest strength. However, the reverse sets in the Humboldt Current are often warmer than the usual waters—observations which are not true of the South Equatorial Current.

The most careful survey of the Humboldt Current was made by the *William Scoresby,* from May to September of 1931, and was reported by E. R. Gunther who found a southward moving, subsurface current of subtropical water always present directly beneath the sub-Antarctic, northward moving water layer. He interpreted this as a return current of compensation which should have flowed at the surface, were it not for the northward movement of the less saline, and therefore lighter, subantarctic water of the Humboldt Current. At Antofagasta, Gunther noted on one occasion that strong upwelling had drawn this subsurface return current to the surface; and again, at San Juan, the current was at the surface and was sufficiently strong to push the motor ship backwards against a stout southerly wind. Gunther did not venture an opinion other than upwelling as to how this current happened to be at the surface.

H. U. Sverdrup, of the Scripps Institution of Oceanography at La Jolla, has called attention to a similar subsurface counter flow under the California Current during its period of upwelling, when it is a "mirror image" of the Humboldt Current. When upwelling ceases in the California Current, the subsurface return current rises to the surface and continues its course, both as a surface and as a subsurface current. It appears likely that this is exactly what the return subsurface current does under the Humboldt Current, for, in a given location, when the upwelling becomes less active or ceases entirely, the return current tends to rise to the surface.

Since it has been proven that the return current is poor in oxygen content its rise to the surface may menace the life in the surface layer accustomed to a habitat rich in oxygen. Thus, strong upwelling without sufficient aeration could prove disastrous, as well as a rapid rise

of the current due to ceasing of upwelling.

The area from which the return current appears to stem has less than ten per cent. oxygen content; its location is in the equatorial belt at depths of 200 and 800 meters, extending from Panama to the vicinity of the Galapagos Islands Besides, it is known that the subsurface current under the Benguela Current off West Africa, which has much in common with the Humboldt Current, is exceedingly low in oxygen value. The only station where oxygen records are available, as indicating the content of the Humboldt's subsurface layer, shows a lower oxygen percentage than that of the Benguela Current. How poor in oxygen the return current of the Humboldt region is has not been reported It is thought that this low oxygen value in subsurface water under the Benguela Current is owing to the enormous amount used up in the process of decay of the vast bulk of vegetable and animal remains constantly falling from the surface through the lower layers. Since there is no evidence to indicate that the life in the Humboldt Current is less than that in the Benguela (the contrary is far more likely), Sverdrup is of the belief that perhaps the subsurface waters under the Humboldt Current are very poor in oxygen also. G. E. R. Deacon, of the British Discovery Committee, found in the far South Pacific that the return current layer had the properties of water that had long been removed from contact with the air; this would mean, among other features, that it is poor in oxygen content. If it is true that the subsurface current under the Humboldt Current is very low in oxygen, and Gunther frequently noted that upwelling came from this layer, the cause for the "Callao Painter" is never far removed from its oxygen-rich surface waters. But whether or not the subsurface return-current has a dangerously poor oxygen content remains unknown.

However, anything that would cause destruction to the life of the Humboldt Current would, also, produce hydrogen sulphide from the resulting decay. Temperature forms a very definite barrier to many life species. In 1941, for instance, M. J. Lobell, of the U. S. Fish and Wildlife Service, noticed that tuna fish in the Humboldt Current area not only retreated with the warm waters but died if caught in waters below seventeen degrees centigrade (62.6° F); on the other hand, anchovies thrived in lower water temperature. Therefore, any warm water invasion into this cool water area results in the migration of various cool water species and the death of many others It may be said that warm water wedges or counter currents are at least one cause of the "Callao Painter." A number of factors have been suggested as producing these eddies and counter currents.

The most famous of the invading currents is that from the north, supposed to be a branch of the Equatorial Counter Current, which takes a southward turn during the strong northerly winds of the northern winter, at a time when the Counter Current is weakest. Its annual infringement upon the normal preserves of the Humboldt Current occurs about Christmas time or shortly thereafter, and is for that reason called *El Niño,* for the Christ Child. Punta Aguja is its usual extreme southern limit, but in 1925 it was reported as far south as Valparaiso (33° S).

Lobell questioned whether the warm waters which reached from the north and west of Peru to northern Chile in 1941 were a tongue of *El Niño;* he did not believe that this was true south of Salaverry (8° 17′ S). It seemed that the more southward waters were series of wedges from the warm open ocean to the westward; and they were similar to those warm water tongues noticed by Gunther in 1931. The warm water invasions of 1941 were much more severe than those

of 1931, for it was noted that thirty miles offshore, "dead birds littered the surface." Except for plankton, little mention was made of dead fish; the cool water fish, absent for the most part, were replaced by warm water forms. In 1941, decaying life produced pronounced evidence of the "Callao Painter."

Both E. H. Schweigger, of the Peruvian Fisheries Department, and M. J. Lobell agree that the warm water eddies of 1941 were accompanied and preceded by southerly winds with a westerly instead of a normal easterly component. Indeed, Schweigger has furnished strong evidence, based upon the records of sixteen years, to prove that upwelling tends to cease and westerly waters to invade the Humboldt Current when the predominance of the average wind direction shows a westerly component; winds with strong easterly component cause upwelling sufficiently powerful to hold back attempted westerly and even unusually large northerly invasions. In Schweigger's opinion, those from the north, attributed to *El Niño,* are caused by a southward shift of the equatorial, low atmospheric pressure.

There are other interesting observations and hypotheses. For example, Robert Cushman Murphy has noted that the Benguela Current and the Humboldt Current were affected similarly in 1925 by warm water invasions, followed by heavy rains and floods and by enormous destruction of marine life. He has stated, moreover, that the phenomena belong in the main to a seven year cycle, possibly connected with sunspots. Otto Pettersson, of the Hydrographic Station at Borneo, is confident that the explanation is to be found in the tidal forces operating on shelf ice in the Antarctic in the years immediately preceding the disturbances in the Humboldt Current; therefore, in Pettersson's opinion, the moon, and not the sun, is the chief factor to be observed pertaining to the northern invasions.

Gunther has suggested that the middle Peruvian warm water wedges might be due to a seiche, sometimes referred to as a stationary wave which is conditioned by the shape, length and depth of a basin's contour. According to H. A. Marmer, a seiche "may be found in any portion of the sea partly bounded by land, for any such area can sustain a stationary wave." Gunther claimed no knowledge of any seiche studies along the Eastern Pacific littoral. (It is interesting to know that the seiche movement in San Francisco Bay was determined precisely by Japanese scientists, who constructed years ago a tiny model of the bottom and sides of the bay, and then placed it in a pond; thus they were able to measure the exact rate and height of any wave in San Francisco Bay originating in the open ocean.)

Seiche studies off central Peru, however, are unknown to the writer, but there is a Milne Edwards Deep, which extends from near the northernmost part of Gunther's warm water wedge of 1931 to its southernmost part, with its deepest portion close to Callao. During the same year, Gunther describes another warm water wedge along the line of deeps in the vicinity south of San Juan Other investigators affirm that warm wedge invasions in these localities are common occurrences.

If the subsurface return current be sufficiently stagnant or if there should be stagnant water on the bottom of some basins, which are not too deep for a local disturbance to bring poorly-oxygenated water to the surface in sufficient quantities to endanger surface water life, the seiche movements might enable the manufactured hydrogen sulphide to produce its effects immediately. That is what the "Callao Painter" appears to do when it is present. As already mentioned, in 1925 the sea birds began leaving or became ill before the warm water invasion arrived. This might be explained if a seiche movement were beginning to dis-

turb the strata in the sea before warm waters arrived. In the absence of further data, it is impossible to express even an opinion as to whether such a movement exists.

Scientists at La Jolla have found recently that "sulphate reducing bacteria are widely distributed in marine deposits" along the California and the Gulf of California coasts; in the diatomaceous muds of the latter vicinity, these oceanographers were able to calculate the rate of hydrogen sulphide production Such bacterial studies in the examinations of the Humboldt Current area fail to exist, so far as the present writer can discover. But diatomaceous mud is the chief marine deposit throughout the length of the Humboldt Current, according to E. Neaverson of the British Discovery Committee. The depth range of these muds on the seafloor of the Humboldt Current extends from twenty-nine meters to more than 4000 meters; apparently, the difference in depth has no effect upon the character of the deposits Neaverson made no mention of hydrogen sulphide formation

Investigation in sewer systems have shown that the production of hydrogen sulphide in the waste becomes a nuisance only when the sulphate-splitting bacteria are not destroyed or, at least, not held in check. A treatment of the bacteria, and not the waste as such, removes the nuisance. If some chemical medication might be applied to the "Callao Painter," the decaying materials might perhaps become less injurious.

There is plenty of waste material in the Humboldt Current at times of major invasion of the area by warm currents, since that flow is unquestionably rich in marine life. The vast quantities of dead bodies inshore and within the harbors putrefy. In the process, the sulphate-splitting bacteria have a part; naturally, enormous amounts of hydrogen sulphide are produced. The greater the destruction of marine organisms, the more evident are the manifestations of the "Callao Painter."

Scientists and travellers alike are impressed with the vast abundance of life within the Humboldt Current. A census of the larger forms of life there has never been taken; perhaps this is impossible. Murphy finds, so far as birds are concerned, that the limits to their increase are not determined by the food supply, for a diminution of the latter has not been observed. Rather, the number of birds in this area has been curtailed by enemies and by available nesting places. With respect to fish, Schweigger has estimated that the guano birds alone remove some 5,500,000 tons per year from this current Fishermen in normal times of cold water find no shortage.

A navigating lieutenant of the British Admiralty has been more specific. During his seven months' stay in Callao in 1882–83, an explosion occurred in that bay. So many fish were stunned that "the water was literally covered. Scarcely any under a pound were thought worth collecting, but the pile on our deck alone must have been about ten feet square and three feet high in the center . . . A heavily laden boat was sent to the foreign man-of-war at Callao, and fishing craft off San Lorenzo were filled Some private communication seemed to exist between San Lorenzo and the pelicans at Old Callao Point, a distance of about three miles; immediately, after the explosion a small number were seen advancing from there in Indian file, and in less than a quarter of an hour there was an unbroken line of these birds right across. . . . I fancy none went away empty"

Off the coast of Peru, Murphy has seen a formation of guanays in the morning take "four or five hours to pass a given point"; when they return in the evening, the white islands turn black with birds which are packed into "the borders of available standing room"

The plankton, upon which all other sea organisms depend, may range all the way from the jelly fish or crustaceans, upon which the largest whales of the open ocean feed, to the tiny, predatory insects on shipbottoms. Throughout large areas of ocean surfaces, a liter of seawater may contain no more than ten of these microscopic living particles. It may be a water desert. While in the Humboldt Current, the research ship *Ohio* in 1924 obtained a count of 1000 or more per liter at twenty-nine stations and as high as 200,000 per liter in one locality. A further serious gap in marine research, as W. E. Allen of La Jolla has demonstrated, is the unsolved problem of space relationships of plankton diatoms which can not be expressed mathematically, "because, at any given point in the sea, sinking may occur according to the formula to-day and not to-morrow, the difference being due to influences added, subtracted, or modified in ways not open to prediction."

Since much of the color of seawater is due to the plankton it contains, the nature and extent of the various colors provide probably a more exact measure of the plankton than would result from the inspection of a liter of water. For instance, diatoms are responsible for the characteristic green of the Humboldt Current, which is at least 2500 miles in length. In this general greenish tint, furthermore, other organisms, which vary in tones like the shadows among the clouds, lend their own particular hues to the different areas.

Gunther found many colors in the waters of the Humboldt Current, yet he added that the tints might not always be due to abundance of living organisms. "Off Pisco . . . the sea was colored ochraceous-salmon, off Callao tawny olive and russet with patches of rusty brown foam, and off the Guanape Islands khaki. . . . Their occurrence at contiguous localities and nowhere else on the west coast, and their occurring where the warm wedge was converging with the coast is suggestive that they might have been forms of aguaje." This was especially true of the rusty colored foam, which was "reminiscent of Stiglick's remark that red aguaje may go away leaving the water frothy."

Johnson and Snook, in their researches on the California coast, have noted that "an aftermath of extensive outbreaks of red water is the decay of inconceivable numbers of microscopic bodies stranded upon the beach, causing very offensive odors, and poisoning the water sufficiently to kill animals such as sea cucumber crabs, and sometimes even fish, with the result that their bodies wash ashore and increase the stench." Similarly, in the Humboldt Current area, there is abundant evidence that the marked temperature features alone are sufficient to account for the migration, impairment or destruction of probably most cool water life

Thus, two different research parties in different Pacific coastal waters, in both of which upwelling, eddies, and rich sea-life exist, noted a connection between red water in particular and an aftermath of stench and death of other sea life. These highly significant parallel findings merit further investigation.

The "Callao Painter" is a highly distinctive, marine phenomenon and mystery. Someday, the scientific reason or reasons for the "Callao Painter" will become known.

SOCIOLOGICAL EXCURSIONS OF BIOLOGISTS

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THE world at war has brought to a head certain very fundamental problems of economics, politics and general social dynamics. More than ever before the common man seeks to know the basic causes for world conflict and the essential reasons behind his own government's foreign policy and political line. Out of a welter of opinion and the tremendous profusion of editorializing in the daily newspapers and radio programs the average man has, at least, arrived at the point of understanding that the theory and practice of fascism derives from concepts which negate the very essence of scientific method and objective inquiry. We realize quite fully now that the corruption of fascist politics and economics has been hidden under the sensationalism of twisted biological theories of the "super race" which have been paraded through journals and books by the "scientific" apologists of totalitarianism

Significantly enough, the world conflict has done more to clarify basic sociobiological questions than the meticulous data of a thousand technical papers. The findings of the natural sciences have usually been thought to be more "down to earth" and therefore more comprehensible to the average layman than the so-called social sciences which have been commonly thought of as being a hopeless muddle. But now we find that the reality of everyday experience is itself an integral part of the development of a scientific social science; it is that close contact with pressing, and ofttimes bitter, social problems that has taught the people much in the way of correct scientific thinking. One of the questions of early evolutionary theory, recently revived by fascist biologists, the existence of so-called superior and inferior races of mankind, has been quite adequately negated by contemporary political and economic history. The people have, by and large, seen through the Aryan myth because of the very practices of fascism itself.

This brings us to the point of the present discussion. It is unfortunately true that certain scientists of democratic lands have written, in connection with biological ideas, particular conclusions which place fetters upon democratic action by their social implications. It is high time that biologists arrive at a political point of view that squares fully with the recorded factual evidence of modern scientific inquiry and with the objective methods of investigation by which those facts were discovered. It is time that the biology of society be based on a study of the human level and not upon laws which operate in the animal world.

It is especially important at this time, when we are in the midst of world conflict, that the historical, political, economic and ideological bases of the struggle be understood by the people. This necessity should make us doubly vigilant concerning our interpretations of social dynamics. We must be even on guard against any adumbrations which utilize Darwin's notion of the struggle for existence, for instance, as a justification for war, in general, on the grounds that this physical struggle is the "chief factor in human progress" Any statement by leading biologists which is not clear-cut in its meaning will be snatched up and utilized for reactionary political purposes by the sympathizers and active tools of fascism.

Certain well-known men of science have from time to time published articles of a more or less general nature concerning social problems in relation to biological concepts which have unfortunately given comfort to the now obsolete theories of social Darwinism. The superimposition of Darwinism and purely biological valuations upon the complex of social and political activity is a fundamental violation of scientific reasoning that has quite disastrous consequences in actual application When we speak of the application of Darwinism or biological laws to society, in the narrow sense, we immediately become identified with a host of well-meaning (in most cases) but politically naive scientists who unwittingly give aid and comfort to the "ideals" which the fascist ideology espouses

Many of these workers in biological science are justly famous for brilliant research in various specialized fields. However, in the realm of sociological thought these scientists somehow divest themselves of the scientific method with which they live in the laboratory and cover their eyes with the nineteenth century spectacles of Herbert Spencer They join in support of the Spencerian notion that social progress is the automatic outcome of evolutionary forces Man, they insist, must not devise schemes and plans for social reform or directed mutation; meddling in the evolutionary process will only bring about disaster—let "Nature take its course " This is the type of thought characteristic of the modern descendants of the "Organicists," who devoted themselves to the mechanical comparison of human society to the structure and nature of biological organisms and their subservience to the "struggle for existence" and the "survival of the fittest "

At the present time we shall not enter into any detailed discussion of the organic fallacy so apparent in the bio-organismic theories of sociology. Here we shall cite the words of certain contemporary scientists to show that this trend in thought, far from being buried, is as alive and kicking as ever.

Biological science, from the time of the publication of the *Origin of Species*, has given us countless factual evidences for the conclusion that man is not a "special creation" but has an organic and historic relation to other forms of animal life. This is a well-known and generally accepted postulate. Furthermore, this knowledge means that certain fundamental biological laws are applicable to human beings[1] Does it follow that human organisms and their society are to be identified with other animals and zoological social forms because certain biological laws are applicable to both?

Evolutionary studies have shown that even the lowly Protozoa developed colonial forms in which there was already a differentiation of structure and function among the separate cells composing them. This specialization and differentiation was carried to great complexity in the whole line of evolutionary transformation Shall we, on the basis of this fact, contend that human society is in reality an organism composed of specialized individuals who are completely dominated by those natural forces which determine the existence of other animals? Can we say, for example, that the dynamics of human life are to be identified with the social insects or the manifestations of "mutual aid" and gregarious habits in many zoological forms? Is it logical to assume that the applicability of laws, generalizations or formulae to a series of different objects reveals the identity of the nature of these objects?

[1] We may, for instance, seek detailed information regarding the types and quantities of acids in muscle during fatigue, the structure of neurons or histological changes induced by toxic principles Obviously, a study of the organism as a whole, in its ecological sense, could not be profitably carried out by such methods.

We can, for instance, apply the laws of physics to a plant, an inclined plane, to man and to the flight of a golf ball Does it follow that a man, a plant, an inclined plane and a golf ball are identical? It is true, of course, that human society is composed of individual organisms which are interdependent and whose activities represent a unity Does this mean that human society is itself a biological organism, since even the lowest form of animal existence is a unity of mutually dependent individuals? A plant, inclined plane, man and a golf ball are all composed of atoms (or smaller physical units) Does it follow from this that all these objects have a similar structure and function and that their activity is a cogent manifestation of identical principles? Obviously, the answer to all these questions is a distinct negative It is quite evident that this type of logical reasoning takes merely the trees into account while forgetting the existence of the wood. On the positive side such logic works in the direction of establishing a bio-sociological ontology which is, to say the least, a dangerous metaphysics that reduces scientific knowledge to the myths and fairy tales of medieval scholasticism so congenial to contemporary fascism

Let us now take note of how certain scientists look at human society Dr. Wm E Ritter, of the University of California, laments the circumstance that ". . . hardly anything is more unfortunate for modern culture and civilization than the very prevalent conception that human society is not natural in the same sense that hymenopterous or avian societies are natural."[2] In similar vein the famous entomologist and biologist, Professor V. L. Kellogg, can not accept the position "of those who persist in wishing and trying to look on themselves and human kind in general as of a different clay, endowed with a different breath, and existing in a different sphere from the rest of life."[3]

Professor C M Child, of Stanford University, admits that "human reactions are much more complex and varied than those involved in development and maintenance of hydroid or planarian pattern, or even of a human embryo. " However, he can not explain this complexity, for its cause can not be found in biological phenomena as such, and so he finally concludes that they (human reactions) "are after all realizations of the same general potentialities of reaction and subject to similar limitations" as are the lowly hydroids and planarians[4]

If human society were a biological entity, the individual would become merely an appendage of the organism carrying out certain specific and specialized functions as do the digestive cells of a sponge or the reproductive cells of a colonial protozoan Here we have a concept which lends itself quite easily to the fascist philosophy of the dominance of the state and the submergence of the individual.

The eminent mathematician, Bertrand Russell, has recently urged that the motive force of human history is "the love of power" which is "the cause of the activities that are important in social affairs " Russell negates the very essence of scientific inquiry by his elevation of a metaphysical entity into the role of determiner of the sphere of real things; by his implication that the "love of power" stands as an absolute and indestructible *élan vital* above man throughout the most diverse forms of social history.

According to Russell, the antagonism between different social strata, such as capital and labor, is nothing more than

[2] Wm. E. Ritter, "Biological Basis of Social Problems," p 169, in *Biological Symposia.* Ed. J. Cattell. Vol. II. Pt. III. Jaques Cattell Press, 1941.

[3] V. L. Kellogg, *Atlantic Monthly.* June, 1921.

[4] C. M. Child, in Cattell, *op. cit.*, p 179.

a reflection of the universal and natural struggle for power even as "competition between organizations is analogous to competition between individual animals and plants, and can be viewed in a more or less Darwinian manner."[5]

To such investigators the development of human society apparently means nothing essentially new in natural history, for history itself is viewed as the outcome of certain ideas which have been operative and established from the beginning of time. Man is simply an animal in another skin obeying drives which were conceived in the very womb of celestial creation. Like Russell, a scientist at the University of California concludes that "the same general laws responsible for the origin of man have continued to operate on him."[6]

This theoretical approach to the meaning of history has completely lost sight of the real and distinctive nature of human society. Scientific inquiry has already shown that human culture (and the human individual taken in the sense of a complete personality) is a product of certain concrete historical circumstances. Man has been distinguished from the animals by a variety of attributes such as consciousness, religion, power of abstraction, power of speech, etc , but actually man differentiated himself from other animals in a fundamental way as soon as he began to produce his means of subsistence. In thus acting upon nature by means of his own physical organization he was at the same time creating the conditions of his material life and culture and creating a new level of existence with independent laws of its own.

Although most scientists agree that the increase or decline of population is to be found in economic and social causes, in some cases an unscientific bias seems to decide the way they interpret the results of this process. We find that their conclusions are not primarily a discovery of the causes and effects of a rise or decline in the birth rate in general, but are much more concerned with the problem of what particular social elements are declining and the particular strata increasing its numbers.

Here Bertrand Russell again seems to have gone astray. "What is regrettable at present," states Russell, "is not the decline in the birth rate in itself, but the fact that the decline is greatest in the best elements of the population. There is reason, however, to fear in the future three bad results: first, an absolute decline in the numbers of English, French and Germans; secondly, as a consequence of this decline, their subjugation by less civilized races and the extinction of their tradition; thirdly, a revival of their numbers on a much lower plane of civilization after generations of selection of those who have neither intelligence nor foresight."[7]

The well-known biologist, Professor S. J. Holmes, also comes forth with a biological formula for man "It may be urged with much reason," he says, "that the birth rate of superior peoples should be kept high in order that they may conquer and supplant inferior types." And again, "since in general officers represent a class superior in intelligence and efficiency their enhanced death rate in war can not fail to have a dysgenic effect."[8]

In making such statements, these observers are unfortunately defending the ideological and practical basis of modern imperialism and the myths of racial superiority. They continually speak of inferior types and of the less intelligent with the same dogmatic certainty that a taxonomist speaks of a well-established biological species. They have, in fact,

[5] B. Russell, *Power*, p. 12, pp. 157–8. New York. W. W. Norton. 1938.

[6] E. B. Copeland, in Cattell, *op. cit.*, p. 204.

[7] B. Russell, *Why Men Fight*, p. 197. New York, 1917.

[8] S. J. Holmes, *The Trend of the Race*, pp 123, 209. New York, 1921.

created a static taxonomy of human society and have classified the so-called lower classes as the inferior type. Like good scientists they then assert that the multiplication of an undesirable type must be stopped if humanity is to survive.

But modern anthropology and genetic studies have shown that we can not identify low economic groups with, let us say, a high incidence of feeble-mindedness. It is true that the subnormal mentality is quite often found in the poorest level of society, but it does not follow that low income is a cause of hereditary mental ineptitude. As a matter of fact, low income itself is the result of certain rather basic economic contradictions which have no more relation to the germ plasm of man than the sun spots have to cyclical depressions. It is not hard to see how such well-meant, but superficial, interpretations lend themselves quite logically to a reactionary social dogma.

Another warning, in similar vein, is given by Carr-Saunders, past director of the London School of Economics. He is afraid for the future of man because "the course of evolution has generally been downwards. The majority of species have degenerated or become extinct, or what is perhaps worse, have gradually lost many of their functions The ancestors of oysters and barnacles had heads. Snakes have lost their limbs and penguins their power of flight. Man may just as easily lose his intelligence . . . if, as appears to be the case at present in Europe and North America, the less intelligent of our species continue to breed more rapidly than the able, we shall probably go the way of the dodo and the kiwi."[9]

We must note that even the interpretation of evolution in the animal world has been seriously distorted by Carr-Saunders. The fact that certain organisms have, in the course of development and mutation, lost many of their former functions and structures is not necessarily a sign that the "course of evolution has generally been downwards." Such a generalization would not be accepted by our leading biologists. The fact that a tapeworm, for example, has lost the complex structure of its ancestors shows us that it has become progressively adapted to a life of efficient parasitism. From the standpoint of an endoparasitic existence the evolution of the tapeworm has been one of remarkable specialization and not degeneration. As far as the snakes are concerned, they seem to get about quite ably without limbs and they have, in their own "degenerate" way produced an apparatus that man has but recently discovered, "and this in the shape of an instrument of immense value to himself—the hypodermic needle"[10]

Has evolution proceeded upward or downward, backward or forward? To seriously consider such a question is to take the step of entering the field of metaphysics and teleological reasoning. In dealing with the factual evidences for organic evolution the biologist does not superimpose anthropomorphic conceptions upon natural ecological systems in order to explain them. Carr-Saunders looks at the limbless snake and reasons that this creature is degenerate because it lacks certain structures found in the highest form, man. He has not made a scientific study of the suborder Ophidia in order to observe if this "degeneration" exists in the facts (he need merely consult authoritative sources to find that the theory is false), but is quite content to distort the findings of genetics and ecology by assuming a morality of progress as operative in evolutionary transformation.

This logic is similarly applied to the view of man. Man is also an animal

[9] A. M. Carr-Saunders, in *Evolution*, pp. 110–125. Ed. by G. R. de Beer, Oxford, 1938.

[10] R. L. Ditmars, *Reptiles of the World*, p. 121. New York, 1940.

obeying the same evolutionary laws as the snakes and barnacles; hence, it is argued, there is a good chance that man may lose his own marks of progress, that is, intelligence (head), hands, speech, etc. Intelligence is considered as solely and directly correlated with hereditary mechanisms and as something quite distinct and isolated from the social context in which it moves. This is not too far from the "blood thinking" of fascist theory.

Here again is that confusion which links economic problems to biological bases, a point of understanding that leads directly toward the camouflaging of our most pressing social problems in a biological arena whose laws have no fundamental relation whatsoever to the forces of the social complex We shall never arrive at any satisfactory solutions to such problems as poverty and dependency until we are willing to see them in their real social aspect The introduction of analogical reasoning from biology for the solution of social problems is the introduction of that type of pseudo-science upon which the theoreticians of the corporative state have based their political-biologics of the super race

Certain men of science expound the theory that all the characteristics of a progressive human culture are inherent in the nature of man. One might say (to carry out this logic), for instance, that the physical predisposition for the ideas expressed in the Bill of Rights was an integral component of the germ plasm of the Founding Fathers. How have these advanced ideas become fixed in the hereditary apparatus? One type of analysis holds that our notions of the rights of man have gone through the process of natural selection during the course of human evolution and have lived because they have a survival value Thus Professor S. J. Holmes concludes that "from the Darwinian standpoint . . . both man's fighting instinct and the higher qualities which lead him to give unselfish service to his fellows are alike produced by natural selection for the sake of their survival value in the struggle for existence."[11]

Similarly, M F. Guyer, of the University of Wisconsin, transforms Mendelism into a dogmatic theory of history by his assertion that "the intellectual, moral and spiritual characteristics which constitute the source of a nation's social institutions and government are in the main but the outward expression of the strong inherent trend that is a part of the very being of the people of that nation Change its racial stock and inevitably its institutions must change Free institutions are but the expression of free men, and the spirit which makes and keeps men free is largely inborn."[12]

These statements imply that human progress can only develop by the special catalytic effect of biological evolution which impresses good cultural qualities upon the genetic structure through the mechanism of natural selection. Man is chained to the biologic wheel; he is able to effectuate social change with about as much certainty as he can direct the evolutionary disposition of the vermiform appendix or the nictitating membrane. For the growth of society "is a vast process, where the forces are massive and act with unhurried deliberation" Man must simply wait for the course of evolution to complete itself; he is, at best, a creature of adjustment. ". . . the elemental forces of the societal realm . . . can not be mastered; they must be studied and known and adjusted to, as a condition of social well-being."[13]

The relation of man to the process of social transformation is thus seen to be

[11] S. J Holmes, *Human Genetics and its Social Import*, p. 277. New York, 1936.

[12] M. F. Guyer, *Being Well Born*, p 396. Indianapolis, 1927.

[13] A. G. Keller, in *The Evolution of Man*, pp. 126–151. Ed. G. A. Baitsell. Yale University Press, 1923.

a passive one and at best man may obtain a more rational attitude toward his fate by study and adjustment. Man's fate "can not be mastered." The implication is that any striving for a better world with the belief that society can be organized and planned scientifically is a mirage and an illusion. Such concepts as "democracy, freedom, self-realization, civilization, nay society itself, are but snares for fools, if they beguile us into revolts against the primary laws which were established in the beginnings of life."[14]

Why is it that these distinguished scientists make the common point of emphasizing the impotence of man in the face of so-called natural forces? Is it not the very essence of science itself to enable society to act upon and change these forces to man's advantage?

One answer has been directly put by Harvard's Professor East He maintains that "... it is probably wiser not to try to change abruptly . . ." the ". . . system of slow and orderly advance . . . Utopias are . . . too revolutionary . . ." Man's ". . . reasoning power is a recent product, his animalism is ancient and firmly established. The student of heredity may well content himself . . . with directing attention to those little problems of every-day life which genetic knowledge may help one to understand, leaving others to pen idealistic constitutions."[15]

Thus the persistence of man's so-called animalism is put as the barrier to social change consciously worked for and directed On this basis it is difficult to understand how man's recently established reasoning power can even cope with the "little problems of every-day life." This is a political philosophy of scientists who believe it is correct to impress a concept of the long and vast process of evolution upon the solution of basic social problems In political practice it gives aid and comfort to the *status quo* ideas now being practiced by the Nazi conquerors in their own educational system and upon the peoples of occupied Europe Overlooked and obscured is the fundamental fact that the slow advance of the little problems finally becomes transformed into a qualitative leap; that change is not evolution taken alone but is, at the same time, a series of social mutations

Any high-school biology student is aware that the history of organisms has shown a development from unicellular to multicellular forms This fact is interpreted by some workers as a sort of guarantee that human society will follow the basic trend of development from autocracy (one-celled) to democracy (many-celled) Is it not clear then, ". . . if evolution is a fact, the change in character of physiological dominance and integration from the autocratic toward the democratic type may perhaps make us a little more hopeful regarding the future of mankind in the course of biological time, even though the character of dominance in some of the social integrations of the present day is far from encouraging."[16]

The future of democratic economic and political systems has thus been guaranteed by the history of biological differentiation and specialization. Even in the face of fascism, which "is far from encouraging," we need merely pursue a course of enlightened isolationism since, in the long run, democracy is certain to arrive like a bus This is an old theory in a new form. It is a bit toned down but, nevertheless, the result of that same philosophical speculative research which induced Ernst Haeckel to call progress "a natural law which no human power . . . can ever succeed in suppressing."[17]

[14] F. C. S. Schiller, *Eugenics and Politics*, p. 32. New York, 1926.

[15] E M. East, *Mankind at the Crossroads*, p. 298. New York, 1926.

[16] C M Child, *op cit.*, p. 180.

[17] Quoted by E. Nordenskiold, *The History of Biology*, p 511. New York, 1928.

It is rather paradoxical to say now that it may take this war to teach biologists that progress and democracy are not natural laws but man-made laws which can easily be negated if they are not consciously and purposefully fought for and worked for. The change from "autocratic" to the "democratic" type is not a product of biological evolution but depends directly upon the speed with which a majority of humanity will sufficiently realize the necessity for democracy to fight for it. The present war has already done much to crystallize such a cognition of the external world

To continue the argument of those who believe that human progress is predicated on biological laws, let us now ask the following question · What is the mechanism established by evolution, within the framework of this supposed irresistible trend toward progress, that will carry on the day-to-day function of integrating the good society? Is it man's intellect, his reason? Is it the consciously applied activity of man in his relation to nature whereby he establishes his material production and likewise changes his material environment and, at the same time, transforms his own nature and his own thoughts? We find the answer apparently in the negative. It is not reason, consciously applied and planned activity, or scientific method; it is "instinct."

> The integrating factors in all animal societies are instincts rather than intelligence . . . even in man, instinct is more universal and more powerful than reason . . . instinct and not reason is the source and ultimate cause of human society as well as of most human behavior.[18]

This was written about a generation ago by a well-known professor at Princeton during the heyday of instinctivist biology. And now, what do we find at the present time?

> Herd instinct is a social qualification The intellect is not. It is individual, in the long run anti-social . . . just as instincts held together the groups of man's predecessors in whatever measure was good, so man's feelings, partly instinctive and all in part instinctive, have always performed this service for him, even in opposition to intellect.[19]

Thus science itself deprecates that greatest of natural historical achievements, the human brain and its distinctive power to reason. It is hostile to an organ which gives man, in contradistinction to all other life, the unique possibility of changing the world in the direction of greater and greater human progress. This, above all, is a crowning piece of defeatism which, were it to become a part of the national philosophy, would set back the advance of democratic states by as much as the contempt for manual skills set back the development of scientific and experimental medicine.

Darwinism, in its contemporary and nineteenth century aspects, does not constitute a biological point of departure which may be utilized to explain and solve the problems of human society. As a matter of fact, Darwin's own evaluation of man in *The Descent of Man* was precisely the same as his treatment of animal development in *The Origin of Species* Man was observed to have been developed from a series of animal forms through natural selection by means of the struggle for existence. *Homo sapiens* was regarded as a true taxonomic species standing on the topmost rung of the ladder of animal development. Man was declared to be an animal.

This was a revolutionary event in itself, since it cracked the stagnating influence of the theological theories of special creation and catastrophism. It did nothing, however, to establish the fact that man's animal relationships were historically of minor significance as compared to the fact that the interaction between man and nature had produced the very materials and mode of a new

[18] E G. Conklin, *The Direction of Human Evolution,* pp. 90–91 Scribners, 1921.

[19] E. B. Copeland, *op. cit.,* pp. 204–5.

type of existence, namely, human society. This, as yet hardly recognized, was the great contribution of materialism in philosophy and the scientific method in sociology.

There is, nevertheless, in a very profound sense, an actual application of Darwinism to society. Here we have reference to the method and the reasoning arrived at by Darwin in order to set up a realistic interpretation of life consistent with the facts in nature. This great contribution to the scientific method was an integral part of that great movement in thought which made possible a higher synthesis in the understanding of natural and human history than had ever been dreamed of before.

What Darwin did was to sweep away, once and for all, the unscientific division between theory and practice, between nature and the facts in nature. This establishment of the scientific method in biology, with its implications for the social sciences, exploded the traditional and static *a priorism* that considered only those forms as legitimate species that fitted neatly into predetermined systematic categories. The problem of understanding the external world became a practical problem and theory was recognized as condensed practice It was the elevation to first rank of the principle that laws and generalizations can only be found in the facts; that they are not immutable but change according to changes in practice—the primacy of practice.

This was truly an intellectual revolution which shook the very foundations under such antiscientific reasoning as that of the famous comparative anatomist, Baron Cuvier, who held the factual evidence for organic evolution in his laboratory but refused to admit the logical conclusion since it did not square with the accepted doctrines of special creation and catastrophism.

Darwin himself was probably unaware of his great methodological contribution. In such ideas as the Pangenesis and sexual selection his reasoning was remarkably akin to the speculative natural philosophy of early nineteenth century German biology. As a matter of fact Darwin actually committed the grave error of applying human concepts to the explanation of biological change, exemplified in his use of the Malthusian doctrine and in his anthropomorphic characterization of certain animal traits. However, these shortcomings, which have been the focus of attack by certain narrow-minded historians of biology, do not detract from the circumstance that his theory of evolution exploded the prevalent idealistic and romantic theories and made changes in nature the connecting links in history rather than changes in ideas.

For the first time it was possible for man to turn scientific reasoning upon his own sphere of existence and find the laws of social dynamics in his own practical activity. But Darwin's method gave man the opportunity of even more than this. It pointed out (on purely biological grounds, of course) not only the important fact that the world is in constant flux and change, but that the relationship between organism and environment is a dialectical antagonism and unity; that every species changes both itself and nature in the process of living;[20] a relationship which is continually in a state of transformation, and an example to man of how he himself had been changed and can still further change the world. This added profound weight to the philosophical proposition

[20] Darwin, in chapter 3 of the *Origin of Species*, states, for example (among a great host of instances), that "if certain insectivorous birds were to decrease in Paraguay, the parasitic insects would probably increase; and this would lesson the number of the navel-frequenting flies—then cattle and horses would become feral, and this would certainly greatly alter the vegetation; this again would largely affect the insects; and this . . . the insectivorous birds, and so onwards in ever-increasing circles of complexity."

that the problem of understanding the external world is, at the same time, the problem of its transformation.

In this sense we find the actual application of the Darwinian or the scientific biological method to the society of humanity. The whole development of modern science with its brilliant achievements in the field of basic productive instruments gives proof of the correctness of the scientific method to which Darwin made fundamental and world-shaking contributions It is unfortunately true that man has only recently begun to think in terms of applying this method to the solution of economic, political and social problems

Today, in the midst of war and fascist reaction, many research workers understand that the application of scientific method finds its own negation in the practice of isolating it from all, but a few, segments of the social milieu Many scientists have at last recognized the vital necessity of repudiating the idea (held by such educators as Hutchins of Chicago) that scientific method and scientific control are the special possession of monks of learning; that the participation of scientists in everyday social and political activity debases knowledge They have seen that science has heretofore been quite irresponsible in its lack of attention to the problems of unemployment, economic depression, wars, fascism, etc, and that, in the immediate past, an unnatural division has been drawn between scientific activity and its social aspect.

Today natural scientists must learn to take a scientific view of the changes constantly occurring in a dynamic society, strictly from the standpoint of the human level; for the entire arena of social action is not only part and parcel of their own lives but the fulcrum upon which the future progress of science in a democratic society is delicately balanced. They must develop their sense of responsibility to a correct interpretation of social events and change, and most important, "they must develop techniques to deal with that continuum. Otherwise they will become passive onlookers upon sequences of events that should be, in some measure, under their control."[21] We do not seek a blind faith in a better world but are confident in the empirical knowledge that men make their own history.

[21] T Swann Harding, "Science and Agricultural Policy," p 1101 *U S Yearbook of Agriculture*, 1940.

PROBLEMS OF THE DEHYDRATION INDUSTRY

By DONALD K. TRESSLER
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During the present emergency, the preservation of foods by drying and dehydration has become a matter of vital importance There are three reasons for this:

First, owing to the shortage of shipping, great emphasis must be placed on the elimination of the greatest possible weight from foods which are to be shipped to Great Britain and to our armies and those of our allies. Since fresh vegetables contain nearly ninety per cent water, while dry vegetables contain only five to eight per cent. water, it is obvious that one pound of dehydrated vegetables has approximately ten times the food value of a pound of fresh, canned or frozen vegetables Since fruits have a much higher percentage of solids, due to their much higher sugar content, the same ratio of advantage does not hold for them However, even in the case of fruits, the dried or dehydrated product has about three times the food value of the fresh product of equal weight

Second, when our armies and those of our allies are on the march, and it is necessary for each man to carry his own ration, it is obvious that the food carried must be in a concentrated form

Third, there is a shortage of tin which may become acute in the near future. In all probability, it will be necessary for us to preserve our perishable foods by means other than heat sterilization in tin containers Of course, glass can be used but our glass factories can not supply a sufficient number of glass jars for all of our canned goods. Further, there are not sufficient cold storage warehouses to permit the freezing and storage of all our perishable foods. Therefore, it will be necessary for us to preserve by dehydration a considerable part of the fruits and vegetables now being canned

Because of the war emergency, dehydration of foods has become one of our major food industries New and improved methods of dehydrating vegetables, fruits and meats have been perfected Admittedly, the present products are greatly superior to those previously offered The big question is. are they good enough to stand competition with fresh, frozen and canned foods? Time alone can tell However, a consideration of the problems of the industry and the shortcomings of the product may give an indication as to what the answer will be

Dehydration Systems

Drying is the oldest and simplest means of food preservation All that is necessary is to reduce the moisture content of a food under eight per cent. and to pack it in a tight container, and it will "keep" indefinitely (i e, remain free from spoilage by microorganisms) Dehydration can be done in currents of warm air or in a vacuum Tunnel driers are most common, although drying cabinets are also being used.

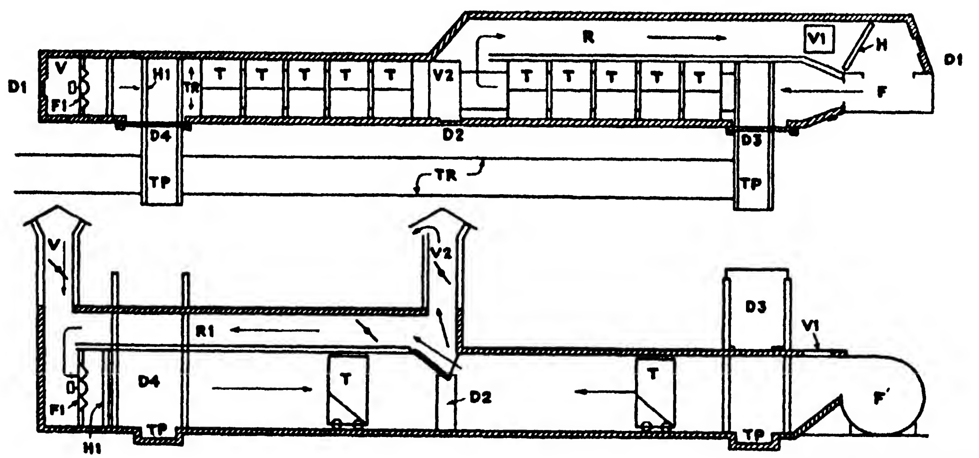
Many different types of drying tunnels are in use In order to dehydrate a vegetable rapidly to a low moisture content, it should first be subjected to a high temperature Later, when the moisture content has been reduced to twenty per cent or lower, the temperature should be reduced to a point below the critical one for the vegetable undergoing dehydration Near the end of the process, the humidity must also be low; otherwise it is impossible to get a product with a low moisture content.

These conditions are easily obtainable in the tunnel designed by Eidt which is popular in the eastern sections of Canada and the United States, being extensively used for the dehydration of vegetables (Fig. 1). This tunnel is constructed in two sections: (1) primary, and (2) secondary. Hot air is blown in at each end and is drawn out at the middle; thus in the primary section of the tunnel the movement of the hot air is in the same direction as that of the product on the trucks, whereas in the secondary part of the tunnel the flow of air is counter to that of the product.

Drying operations are somewhat more easily controlled in a cabinet dehydrator, but the capacity per unit of floor space is less. In the cabinet dehydrator, the trays of food are placed on a truck which in turn is moved into a chamber in which the air is drawn through a fin type steam radiator by a blower which blows the air over the product at a velocity of 600 to 1,200 linear feet per minute. Only a portion of the warm air is exhausted; most of it is recirculated through the radiator and then again over the product

Vegetable "purées" and some milk and eggs are dehydrated on drum-driers. A drum-drier consists essentially of a steam or hot-water-heated revolving drum made of corrosion-resistant metal. The liquid, or purée, is spread in a uniformly thin film over the drum as it slowly revolves. In thirty to sixty seconds, when the drum has made about two-thirds of a revolution, a thin film of the dehydrated product is scraped off. Because of the great speed at which drying takes place, the quality of drum-dried products is excellent The main disadvantage of the process is that it is not suitable for the dehydration of either whole fruits or vegetables or even small pieces of these products.

Liquid products, such as milk and eggs, may either be drum-dried or spray-dried. Spray drying is carried out by



Courtesy Food Industries

FIG. 1. AN EIDT TUNNEL DEHYDRATOR

T, Trucks; Arrows Indicate Direction of Air Flow; R, Air-Return Duct Between Finishing Chamber And Fan; R1, Air-Return Duct Between Primary Tunnel And Finishing Chamber; F, Conoidal Fan to Circulate 40,000 Cu. Ft. Per Minute In Primary Chamber; F1, Propeller-Type Fan To Circulate 20,000 Cu. Ft. Per Minute In The Finishing Chamber; H And H1, Heaters For Primary And Secondary Ends Of Tunnel Respectively; D, D1, D2, Two-Foot Door To Allow Entrance To Fans And Heaters, And To Make Truck Exchanges In Tunnels; D3 and D4, Counterbalanced Doors To Allow Intake And Outtake Of Trucks; TP, Transfer Pits; V1, Intake Duct For Use When Finishing Chamber Is Not Operating; V, Intake Duct; V2 Outlet Duct; TR, Track; Shading, Insulation.

atomizing a liquid or semi-liquid product in a special chamber into which hot air is blown. The liquid evaporates so rapidly that it remains relatively cool until it reaches the cooler zone of the drier. Most of the powder falls to the floor of the chamber. That which is entrained is caught in bag type dust collectors equipped with automatic unloading devices.

Large quantities of milk, eggs, lemon juice and a few other liquid foods are dehydrated in spray-driers.

Problems of Vitamin Conservation

Dehydration processes are simple, but if one is to retain the full palatability and nutritive value of the food, the problem is far more complex In general, the methods now employed for the drying and dehydration of fruit conserve the nutritive values of the fruit well, with the exception of its vitamin C content. If the fruit is sulfured during process of preparation, the vitamin C content is retained, but vitamin B_1 is destroyed What is needed is some agent which will prevent the darkening of the fruit and also preserve both the vitamin B_1 and vitamin C content.

The problem of preserving the full palatability and nutritive values of vegetables during dehydration is even more difficult During the last war, most of the dehydrated vegetables produced were lacking in flavor, texture and nutritive value. Since then we have learned that it is absolutely necessary to scald the vegetable before dehydration. Scalding not only improves the palatability of the freshly dehydrated product, but also permits the storage of the dehydrated vegetable for considerable periods without marked loss of flavor and color. It also aids materially in conserving the vegetable's vitamin content, particularly vitamin C.

Another noteworthy improvement is the dehydration of vegetables in two stages. Stage one is accomplished at a relatively high temperature (180 to 200° F). As long as the food is moist, it will remain cool, owing to the rapid evaporation of its moisture in the rapidly moving air of relatively low humidity. When the food becomes nearly dry, evaporation slows down, and the product warms up nearly to the temperature of the air; it must then be moved over into another part of the dehydration equipment in which the second stage of dehydration is carried out The latter is effected at a point somewhat under the so-called "critical temperature" for the vegetable being dehydrated In the case of onions, this temperature is about 140° F. The critical temperature of cabbage and saurkraut is approximately 145° F. Some other vegetables—for example, beets—may be finished at a temperature as high as 165° F.

In general, properly scalded dehydrated vegetables prepared under optimum conditions retain all of their nutritive values well, with the exception of vitamin C. Work carried out at the New York State Agricultural Experiment Station[1] determined the losses of vitamins occurring during commercial dehydration of cabbage, rutabagas, beets and potatoes. Relatively small losses of carotene and thiamin and large losses of ascorbic acid were observed. The data are summarized in Table 1.

Researches now in progress promise to reveal how vegetables may be prepared and dehydrated without marked loss of vitamin C. Preliminary studies seem to show that if the vegetables are scalded with superheated steam or steam under pressure, a much higher percentage of the vitamin C is retained than if the product is scalded in boiling water or ordinary live steam.

[1] D. K. Tressler, J. C. Moyer and K. A. Wheeler, 1943. "Losses of vitamins which may occur during the storage of dehydrated vegetables." *American Public Health Journal*, Vol. 33, No. 8, 975–979 (1943).

TABLE 1

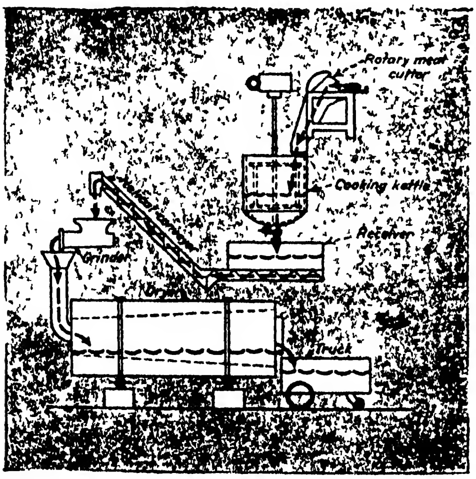
LOSS OF VITAMINS DURING COMMERCIAL DEHYDRATION OF VEGETABLES IN CABINET DEHYDRATOR

Vegetable	Per cent loss during dehydration		
	Carotene	Thiamin	Ascorbic acid
Cabbage	(a)	5 4	19
Rutabagas	9 0	16 7	87
Beets	(a)	19 5	29
Potatoes	(a)	24.6	100

(a) Not determined—little carotene was present in the original fresh vegetable

DEHYDRATION OF MEAT

Meat is now being successfully dehydrated on a very large scale. Fresh beef is first cut up, then cooked under steam pressure The cooked meat is ground and then fed into a rotating drum of a horizontal dryer (Fig 2) in which air heated to 300° F is forced at a velocity of approximately eight hundred feet per minute through the tumbling mass of



Courtesy of Food Industries

FIG. 2. FROM THIS DIAGRAM OF THE PRODUCTION LINE FOR DEHYDRATING BEEF THE RELATION OF EACH OPERATION AND PROCESSING UNIT TO THE OTHERS CAN EASILY BE SEEN.

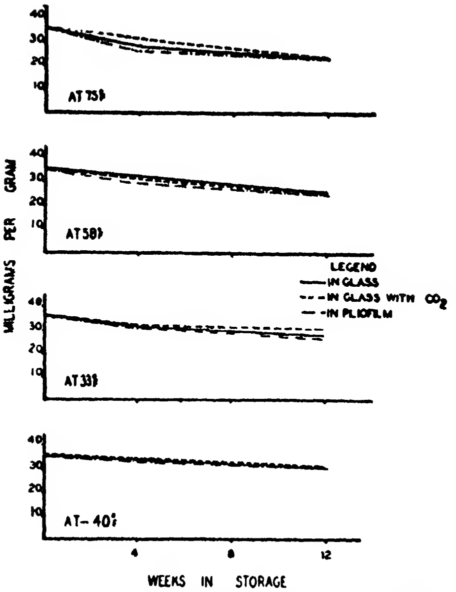
finely divided meat. Dehydration is accomplished in about two hours. The product resembles cooked, not fresh, meat Consequently, it is suitable for use in hash, meat-loaf and the like. Dehydration carried out at a very low temperature is the only method that has been found that will yield a product substantially the equivalent of raw beef. According to this process, the meat is first frozen and then, while frozen, dehydrated in *vacuo*. The product is excellent but the cost of production is high.

In the case of most dehydrated meat and meat products, the fat content offers difficulties because it tends to turn rancid during long continued storage Anti-oxidants are needed which will inhibit this action. Guiac gum is being used by some packers to retard the development of rancidity

The dehydration of whole milk offers more obstacles than the dehydration of skimmed milk, since here again it is necessary to stabilize fat in such a way that it does not turn rancid during storage. Packaging of the product under high vacuum or under an inert atmosphere, such as carbon dioxide or nitrogen, retards—but does not stop—the development of rancidity.

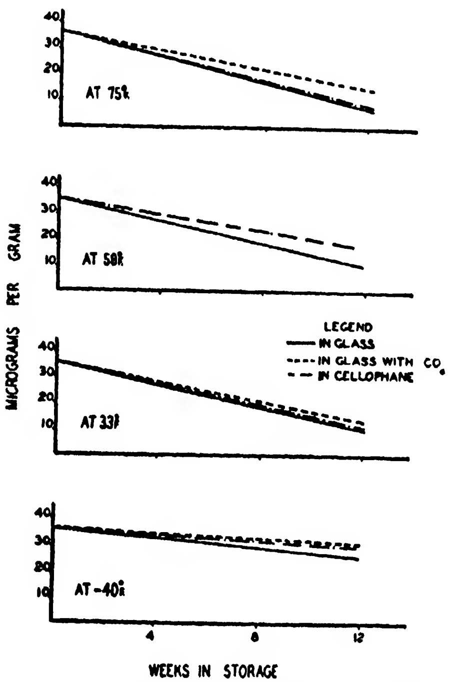
STORAGE PROBLEMS

Most freshly dehydrated vegetables are of high quality, comparable in color and flavor to the original vegetable, but gradually decrease in flavor, color and vitamin content during storage. In some instances, off-flavors develop and the product turns dark in color. Onions, cabbage, carrots and sweet potatoes deteriorate in storage somewhat more rapidly than the other vegetables commonly dehydrated At ordinary room temperatures, for example 70° F, the rate of deterioration is relatively slow. Thus, even the products listed above retain their quality for six to nine months. If, however, the temperature is raised to



From Tressler, Moyer and Wheeler

FIG. 3. ASCORBIC ACID CONTENT OF CABBAGE IN STORAGE.



From Tressler, Moyer and Wheeler

FIG. 4. CAROTENE RUTABAGAS HELD AT VARIOUS TEMPERATURES.

90 to 100° F, the loss of quality is very rapid, particularly in the case of the four vegetables named If these products are packed under carbon dioxide or nitrogen, their palatability, color and vitamin content are retained somewhat longer

Storage losses of carotene and ascorbic acid are much greater than those of other vitamins Thiamin losses are negligible Refrigeration aids in retarding losses of both carotene and ascorbic acid, but the temperatures must be very low if the losses are to be reduced to a minimum (Figs 3, 4, Table 2).

The lower the moisture content, the slower the rate of loss of quality and vitamins at any given temperature[2] However, it is difficult to remove the last few per cent of moisture from these vegetables

From the above, it will be seen that, if dehydrated vegetables are to be stored for a considerable period of time, it is important first to reduce the moisture content to the lowest level practicable and then to store the products under refrigeration If these precautions are taken, any of the dehydrated vegetables can be maintained in excellent condition for a year or even somewhat longer

Dehydration results in a very great reduction in the weight of the vegetables However, loosely packed dehydrated vegetables occupy a relatively large volume per unit of weight. During the past year or two, it has been found that it is a relatively simple matter to compress most of the vegetables commonly dehydrated into small blocks, usually called "briquettes" In the case of dehydrated cabbage, for example, it is possible to compress the contents of a five-gallon can to a volume of approximately three quarts, thus effecting a seven to one compression If the dehydrated vegetables are to be shipped overseas, space saving is almost as important as weight saving.

[2] E. M. Chace, "The present status of vegetable dehydration in the U. S," 1942 Proceedings Inst. Food Technologists.

TABLE 2

ASCORBIC ACID CONTENT OF STORED DEHYDRATED RUTABAGAS*

Period, months	How stored	Storage temperatures			
		−40° F	33° F	58° F	75° F
0		0.42	0.42	0 42	0.42
1	In air in glass container	0.32	0.47	0.28	0.36
	In cellophane bag	0 47	0.47	0.36	0.38
	In CO_2 in glass container	0.38	0.60		0.39
2	In air in glass container	0.27	0.45	0 43	0.26
	In cellophane bag	0.34	0.55	0.26	0.24
	In CO_2 in glass container	0.34	0 36		0.35
3	In air in glass container	0.38	0.35	0.37	0 31
	In cellophane bag	0.44	0.40	0.38	0.43
	In CO_2 in glass container	0.43	0.46		0.34
4	In air in glass container	0.41	0 21	0 18	0 16
	In cellophane bag	0.38	0.26	0.19	0.19
	In CO_2 in glass container	0.42	0 34		0.17

* From Tressler, Moyer and Wheeler, loc. cit.

It is of importance to use just sufficient pressure to compress the vegetable so that it will remain in a solid block when the pressure is removed, and not enough to cause it to be pressed into such a solid block that refreshing can be accomplished only with great difficulty. It is evident that briquetting will become important only when the resultant blocks can be refreshed in a relatively short period of time.

IMPORTANCE OF PROPERLY COOKING DEHYDRATED VEGETABLES

Although many persons have been engaged in researches to determine how vegetables may be dehydrated and the product stored without marked loss of nutritive values, only a few have given consideration to those methods of cooking which will prevent serious loss of vitamins during preparation for the table It is evident that losses which occur during final preparation are just as real as those taking place during dehydration and storage. Researches carried out by Fenton and co-workers[3] have shown that increasing the volume of cooking water from the minimum amount required caused a very marked decrease in the amount of thiamin and ascorbic acid retained by the cooked dehydrated vegetable Perhaps this should have been expected since these vitamins are so easily soluble in water Steamed vegetables were found to retain about the same amount of the water-soluble vitamins as those boiled in a small amount of water without previous refreshing

Regardless of the method of cooking, no actual destruction of thiamin was noted, although when dehydrated vegetables were boiled in large amounts of water, much was dissolved and lost in the cooking water. More work should be done to show how preparation losses may be kept low.

During the past few years, dehydrated soups and dehydrated soup mixtures have become popular. Many of the products prepared by mixing dehydrated vegetables, dehydrated milk, soybean flour and monosodium glutamate are ex-

[3] F. Fenton, B. Barnes, J. C. Moyer, K. Wheeler and D. K. Tressler, "Losses of vitamins which may occur during the cooking of dehydrated vegetables." *American Public Health Journal*, Vol. 33, No. 7, 799–806 (1943).

cellent, being fully the equivalent of those which may be produced in the home kitchen. Furthermore, they are simple to prepare, requiring only the addition of boiling water.

Home dehydration is becoming an important practice. Owing to the scarcity of commercially canned, frozen and dehydrated vegetables and to the shortage of equipment for home canning and freezing of vegetables, many housewives are turning to home dehydration as a means of preserving their surplus vegetables and fruits.

The state experiment stations have published directions for the dehydration of all kinds of vegetables and fruits, and are also furnishing plans and directions for the construction of dehydrators which may be used in the kitchen.

Recently, the War Production Board has authorized the construction of 100,000 home dehydrators well adapted for kitchen use. An excellent type of home dehydrator consists of an electric heating element, an electric fan and a thermostat housed in a cabinet containing a number of trays on which are placed the vegetables or fruits which are to be dehydrated. The fan blows air heated by the heating element over the trays. Usually the air is continuously recirculated; only a small amount of moist air is continually exhausted and an equivalent quantity of fresh air is drawn in. The principal differences between commercial cabinet dehydrators and the better ones now offered for use in the home kitchen are size and source of heat, most commercial dehydrators using steam.

Housewives willing to take the trouble to prepare vegetables and fruits properly will be able to produce a product comparable in quality to that of the present commercial preparation. The general use of these dehydrators will mean a great increase in the quantity of perishable foods preserved in the home.

The future of the dehydration industry will be bright in post-war days if the storage problem can be solved If serious losses of quality occur during the period that dehydrated vegetables are on the grocer's shelves, the quality of the vegetable offered the housewife will be variable If the products are not properly stored, the housewife will literally, and figuratively, have a bad taste in her mouth and will not continue using dehydrated vegetables when she can purchase unlimited quantities of canned and frozen vegetables of high quality.

RACIAL STATUS AND PERSONALITY DEVELOPMENT

By ALLISON DAVIS

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RACIAL dogma, with its network of folkways, maintains that the bodily marks which differentiate between groups of men externally likewise divide them into groups of the pure-blooded and the impure-blooded, of the cultured and the uncultured, of the ambitious and the lazy, or the politically capable and the politically incapable.

These powerful ramparts of unreason, of folk-lore, of group dogmas and hostilities have been referred to by Dr. Redfield[1] as constituting what he called "a modern mythology." In brief, this mythology of race states first, that a man's typical behavior, whether biological, social, political, educational or psychological, can be predicted upon the basis of his physical appearance and attributed to his racial inheritance; it holds secondly that the physical stocks of men are innately unequal in many of their important functions, and that changes in environment will not stimulate changes in these relative inequalities.

As a biological scientist, Dr. Krogman[2] had a swift and complete victory in his part of this tournament of lancing against racial myths; for, as he said, there is no proof either that the bodies of one race of men are less well adapted in themselves to survival than those of another, or that those physical differences which distinguish in a general way between physical stocks of men have any bearing upon the intellectual or cultural behavior of these races of men.

This social behavior by which one distinguishes between groups of men is not racial, but cultural, in origin, Dr. Redfield next pointed out; and it is cultural, he would say, in the sense that it is the product of the social experience of the individual in that particular way of life (that culture) which has constituted his social environment Not race but society determines man's culture and psychological behavior; the best evidence for this conclusion is, as Dr. Redfield said, that all cultural behavior is learned behavior. None of it is inherited in the blood stream, nor in the genetic structure; none of it is transmitted by the mere fact of membership in a certain race, nor even by the mere fact of birth into a certain family. All of this social or cultural behavior must be learned by each new human organism through the laborious processes of imitation, identification and the other learning processes. Dr. Redfield thus disposed of the myth that race is at the basis of cultural differences by pointing out that men learn their culture (including, he said, their racial attitudes which they lack as young children). Since culture is not transmitted biologically, physical race has nothing to do with it. Not his race, but the kind of a society, the type of institutions, the degree of economic and social opportunity which the individual finds available to him will determine the richness and complexity of the culture he learns.

Perhaps the belief in racial or ethnic types of personality is the most common and spontaneously expressed form of racial dogma. For example, southerners are taught from early life that Negroes, as a group, are childish, irresponsible, lazy and primitive. Italians, so our

[1] *The Scientific Monthly,* Sept., 1943.

[2] *The Scientific Monthly,* Aug., 1943.

American folklore and popular literature tell us, are carefree, artistic, sensuous and hot-tempered. Filipinos, as seen by western eyes, appear innately vain and childish in their love for display, as well as irresponsible and frivolous. Even the Yankee has been considered, at least by certain other nationalities, to have a "racial" personality; he is supposed to run to the money-grasping, uncouth, aggressive type, and from the European viewpoint to be culturally naive and unsophisticated. Since there have always been numbers in each of these groups who exhibited the behavior which the myth said was inherent in their "racial" nature, it followed that anyone who believed the myth about Italian or Negro or Yankee personality could find some choice cases to confirm his emotional belief. The fact that the majority did not exhibit this stigmatized behavior did not discredit the myth for those who were taught to believe it. Furthermore, there is a general conviction in our society that personality, or character, is inborn, inherited, or predestined. Thus it is generally believed that nothing can be done to change personality; one is supposed to be born with it, just as one is born with race. For this reason, the myth of racial types of personality is even more deeply rooted in our folklore than is the myth of racial types of culture. Many in the general public may come to agree that a man's culture is a function of his social environment; that culture is learned. But very few will so agree with regard to personality. In the popular thought, personality itself has something elemental and instinctive about it. What could be more natural, then, than to expect a Filipino, an Italian, a Negro, an Oriental to have an inborn, "racially" characteristic personality? They are supposed to have been born that way, and nothing, it is assumed, is capable of changing them.

Yet the great students of human social development, and of the human psyche, have now made it clear that personality is also a learned pattern of behavior. The differences between babies at birth, no matter what their race, are very slight, and are limited chiefly to differences in physical responses. As soon, however, as the baby's mother and his family begin to care for him and to interact with him socially, they begin to offer a learning environment for him which differs from that of every other baby in some respects Through this association with his mother and his family, through the processes of his early training with its relative severity, its skill in using rewards and punishments, and through his changing emotional relationships with his parents, and brothers and sisters, the child is actually learning that characteristic disposition toward people and situations which we term personality To protect himself, to win favor, to outdo a brother, to escape from a hostile parent, or a dangerous adult, a child learns to be fearful, or aggressive, or stoical, or vengeful At the same time, he learns to act as children in his cultural group are required to act; he learns to be a Samoan child, or an Italian child, or a low-status white child in the South. He learns this cultural personality because it is the only kind which is acceptable in his society. A Park Avenue family insists that its children learn upper-class culture, and a poor slum family insists that its children learn the kind of cultural behavior which is considered proper and which will gain them acceptance in their slum community. Now, at the same time that the child is learning how to be a slum boy or a Park Avenue boy, he is also learning his own private adjustment to the world. Both these aspects of development are a part of personality, and each is learned. Neither of them is biologically determined or influenced by race.

Personality is a very complex aspect of human behavior, but let us see if we may state more clearly this dual nature

of human personality, which each of us actually recognizes in his daily experience with people.

You meet a man on a train, and spend the better part of the day in that surprisingly personal type of conversation which is safe with a person who will never see you or your friends thereafter. You recognize two things about him by the time the day is over; he is a man from a rural tenant community, and he has, for some reason, a need for constant boasting. These two facts represent the two chief areas in personality: that of the culture which forms a man, and that of his private, individual life of fear, or courage, or hate, or guilt.

I shall call the latter the private, or individual, personality, and the former the cultural personality. The cultural personality may be defined as that system of human behavior, thought, perception, emotion and values which is taught by the culture. It includes one's behavior as a male or a female, a child or an adult, a slum dweller or an aristocrat, an Italian or a German in a particular community. The cultural personality is extremely complex for most individuals in our society; for example, the same woman often has to learn the social behavior, sentiments, and values of a daughter, a sister, a wife, a mother, and a grandmother! The cultural personality may be so marked as easily to distinguish an individual as a member of a cultural group, at least for anyone who knows the culture of that group. Thus one could tell a southern poor White, or a Samoan, or a Londoner, or an Australian.

On the other hand, one could not tell a man's culture by his greed, or love of art, or boastfulness, or laziness, or meanness of spirit, for these are traits of personality exhibited by some members of all cultures. They reflect the private or individual personality. The private, individual personality is perceived in that behavior of an individual which distinguishes him from other individuals, even in the same cultural group. In this personal sense, one Samoan is not like all other Samoans; in his individual personality he may be like one's own best friend or best enemy in America!

With this distinction between the two basic aspects of personality in mind, it is possible to consider more objectively the major question before us: What effects does racial status exert upon personality? Italians, Mexicans, southern Whites, southern Negroes, Spanish, and Indian peoples are here considered as social groups, or as what Dr. Redfield termed "socially supposed races" (in the popular thinking). Each of these social groups has a culture, or a number of cultures. Perhaps it is more important for the formation of personality that each of these groups has a status, or a number of types of status in a larger community (or region, or nation). For example, Spanish families in Mexico have the highest status there, as do old white planter families in the South, or old Yankee shipping families in New England. Subordinated to these Yankee aristocrats (in New England communities) in ethnic or, if you will, racial status, are the French Canadian, Polish, Italian and other foreign-born or nationality groups; subordinated to the Spanish families of Mexico are various intermediate groups, with the Indian masses at the bottom; subordinated to the southern white aristocrats are also various groups with the poor Whites and Negroes having the lowest status.

Clearly, membership in an ethnic or racial group which has superior status in a given community is a psychological gain for an individual. It frees him by the very fact of birth from a whole system of limitations, punishments and stigmas to which the members of a subordinate race are subject. The "old Spaniard" in Mexico, the "old American" in

New England, or the White in the South is assured of prestige, social dominance and freedom from systematic subordination on grounds of race, even though he may be a very poverty-stricken, illiterate person. High racial status, therefore, affords to those who possess it a customary, daily psychological security and social prestige which they do not have to earn. To phrase this gain negatively, high racial status protects an individual against the inevitable restrictions, punishments and frustrating taboos to which people of low-racial social status have to submit. High racial status likewise affords an individual the right and the opportunity to be paternalistic, to grant favors and protection, to receive deference and supplication

What of the psychological responses available to the members of a socially subordinate race? First it must be remembered that the degree, or type, of subordination of racial groups varies. The subordinate status of the foreign-born immigrant in Chicago in relation to the older American group is much less marked than that of the Chinese in California to Whites; the subordinate status of Negroes in the South, and in South Africa under the British and Boers, is actually a condition of caste as rigid as that described by students of Hindu caste.

Severe subordination of a race means limiting the number of economic, social, educational and political roles it can learn; psychologically it means the narrowing of the number of types of responses which the individual can make. In a vast number of economic and social relationships, prestige and attainment are taboo to the member of a subordinate status. He must learn either to be deferential and compliant, or to be aggressive only to the degree and in the situations considered permissible to one of his racial status.

It is not necessarily true, of course, that the most rigid subordination necessarily leads to the greatest frustration of a racial or social group. A group may be so thoroughly subordinated and so cut off from full human participation in the area where it exists that it becomes hibituated to those substitute goals and forms of gratification which it is allowed. On the other hand, the member of a race which, although allowed to gain high economic or educational or political status is nevertheless denied social status, may experience far more frustration and personality disorganization than a member of the first group. In this country, however, where every one has learned the dogmas of democracy (of the equality of citizens before the law, of opportunity, of the brotherhood of man), it is true that all subordinated racial groups certainly feel deeply the penalties which are directed against them as a result of their racial or ethnic marks.

I wish to call attention to several factors, other than the degree of racial subordination, which help determine the effect of this subordination upon personality Before proceeding further with this consideration of racial status, however, I must bring into the picture the other principal influence upon racial experience, namely, culture.

In our modern world, where economic imperialism has brought all races into cultural contact, the individual of a subordinate race is often a man who has learned the ways of two different cultures. In all such cases, the two cultures have different status or rank, from the point of view of either race. In most cases, as was true with the American Indian, the culture of the subordinate race gradually lost status with its own group. Thus in the case of the detribalized or socially disorganized people of Africa, or Burma, or the Pacific, the European culture gained higher prestige in the natives' eyes than their own. The situation is paralleled by the experience of the poor European immigrant in

this country. He gradually learned the culture of America, and came to prefer it to his foreign culture, which he still exhibited. His children not only preferred the American culture, but were very likely to be ashamed of their parents' foreign culture

These men of two cultures (and sometimes also of two races) have been called "marginal" men by Dr. Park The important point about the marginal man is that his two cultures do not have equal status, in either his own eyes or those of his neighbors. One is a superior culture, as he sees it, and the other an inferior. Fifteen years ago Dr Park wrote, "It is in the mind of the marginal man that the moral turmoil, which new culture contacts occasion, manifests itself in the most obvious forms "[3] The nature of this frustration and humiliation in the child of the immigrant is illustrated by the following excerpt from a famous autobiography:

> I was an alien in my mother's home. I loathed it . . . Oh, it was not the poverty I minded! . . . But the women who came in their slovenly dresses, content in their stupidity . . . , the men who spoke intolerantly and without understanding of religion and economics, the pale girls who simpered and toiled with the one aim of a dreary married life, the young men who were untidy and dull, or overbearing and conceited when they had education—that was what I saw. . . .[4]

Among the Spanish-Indian urban people of southern Mexico, Dr. Redfield has found a marginal group, intermediate between those of Spanish culture and those of Maya Indian culture—a group which illustrates the great complexity of these situations in which races of different cultures meet.

> This [marginal] group may be subdivided into three. the households of Maya-speaking mestizos who have specialized occupations: those, some simple agriculturalists and some specialized workers, where the language is Maya but where the man wears the city costume· and those, where likewise the occupation is various, where the women wear folk costumes (the men having in most cases taken to wearing some of the garments of the city), but where the language of the home is Spanish.[5]

The psychological impact of subordinate racial status upon the member of such a group also depends upon his social status within his own race. The lower-class Oriental farm laborer in California does not experience the same sense of exclusion and isolation as does the high-status Chinese whose family is old in American culture, but is still subject to racial stigmas. The Italian of "Little Italy" is not subjected to the pull of two worlds—and two sets of psychological and status evaluations of these worlds—as is the second or third-generation Italian who has moved to the residential suburbs As the more acculturated members of subordinate groups attempt to change their status by changing their culture, they become increasingly aware of their ethnic status and hostile to their old culture. At the same time, they are also increasingly subject to punishment from members of the dominant group, which resists the efforts of the marginal men to enter their group.

Where the social group of the racially subordinate individual is highly organized and integrated as in the Little Italies or Chinatowns, or in many southern Negro communities, its members will usually have relatively less psychological conflict over their racial status. Their world is a little society in itself, with strong limitations upon cultural contact. Such situations tend to prevent sharp awareness of their subordinate status by those who live in the segregated community. They are to be contrasted with the marginal type of situation in which a European immigrant

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[3] Park, Robert E. "Human Migration and the Marginal Man," *The American Journal of Sociology*, 33: 893, 1928.

[4] Stern, E G. *My Mother and I*, quoted in Stonequist, Everett V. *The Marginal Man*, Ph.D. Thesis. University of Chicago, p. 242. 1930.

[5] Redfield, Robert. *The Folk Cultures of Yucatan.* University of Chicago Press, p. 65. 1941.

(in this country), an Oriental or a Negro is living in a neighborhood with American Whites, and is participating in economic or other situations in which he is seeking similar types of status as the American.

An individual's racial status may be expected to have marked effect upon his personality, then, if his race is subordinated in community relationships, if his group is ashamed of its culture and seeking the culture of the dominant group, and if it has no integrated society of its own In addition, the age of an individual is a crucial factor in determining the scars of racial status upon his personality The American Youth Commission's recent studies of personality development among Negro children in southern cities revealed that their racial status had a somewhat minor influence upon their personalities During both the first and second decades of life, these children were more deeply concerned with, and emotionally influenced by, their family, their play-group, their school and church, than by their consciousness of their subordination to Whites. This fact I attribute to their relative lack of direct contact with the white world at that age. As they completed their education, and sought jobs from white businesses, however, they met the full impact of the economic blockade which is maintained against their group by southern Whites The parents of these adolescents, however, were also interviewed extensively; they showed unmistakable evidence of deep frustration, disillusionment and cynicism concerning their opportunities as Negroes in those cities For both white and colored persons, it appears certain that race attitudes and their effects upon personality become far more strongly developed as they go through adolescense to adulthood and parenthood; as they grow older, that is, they learn that their status and opportunities for full human participation in this civilization are vitally affected in a great many points by racial prestige or racial stigmas.

The Italian immigrant child, the Chinese child, the Negro child in this country does not meet most of the racial taboos; but his father meets them daily. Thus the escape and withdrawing reactions, or the negativistic, or the aggressive responses of such adult personalities may be deeply intensified by their adult experiences of the full significance of the economic, educational and political barriers which are organized against them upon the purely arbitrary basis of their racial or ethnic group membership. In the second, or acculturated, generation, the old are the bitter. At the very least, they are the disillusioned.

The fact that racial subordination is a basic psychological deprivation, and the fact that individuals must learn the kind of behavior required by their racial status are illustrated by the reactions of Negroes in the South There, the population is divided into two castes, Whites and Negroes One can never change his caste marks, nor his caste status. He is born in his caste, and he must die in it. He can neither earn, nor learn, nor fight, nor marry his way out of his caste. That is why it is, in reality, a caste. Not only are the castes separated, but they are ranked in a hierarchy; the White caste is assured economic, political, educational and social dominance by law, custom and force.

It is difficult for Whites in the deep South to understand the feelings of Negroes in their lower-caste positions. In the first place, as soon as he begins to live in the South, a White is taught the social dogma of his caste with regard to Negroes. On every hand, he hears that Negroes are inherently childish and primitive. He is taught that they lie and steal impulsively—"like children"—that they are unable to control their sexual urges, and that they

share none of the complex social and economic ambitions of Whites. Since Negroes are primitive and childlike, the story runs, they accept their restricted opportunities as matters of course (although children themselves do not do so), and consequently they feel no pain or deprivation in performing the heaviest, dirtiest work, or in undergoing the severest discriminations In many essential points, the southern dogma concerning Negroes is the same as that held by the slave-owning classes almost a century ago

The second difficulty which Whites meet in understanding the experiences of Negroes as lower-caste people is the rigidity which the caste system has attained in the South. Negroes and Whites, for example, seldom have face-to-face relationships, except in necessary economic transactions. In those immediate relations which they do have with Whites, Negroes must always act deferentially. In life, this means that the colored individual seldom expresses to Whites, by word or by action, the frustration or resentment which he may feel toward them. On the contrary, he must dramatize his subservience by using deferential forms of address, and by accepting without open aggression those punishments with which the Whites subordinate him. To a White who observes Negro behavior from his own caste position, therefore, Negroes may appear perfectly accommodated and happy.

Yet we know that Negroes in the deep South are continually expressing to each other the deepest sense of frustration over their position in society. They verbalize these tabooed feelings only to their colored friends or to colored interviewers, and to northern white men—that is, to members of those groups which will not punish them for such expressions. In order to penetrate the rigid surface of the caste system in our own South, and to get at the human experiences and motivations which are imbedded in the tough, protective layers of custom, one must talk with people in their own terms, therefore, and live in their part of society.

When social psychologists have studied Negro personality in this intimate way, they have concluded that southern color caste must be viewed as a systematic interference in the efforts of a special group of individuals to follow certain biological and social drives. This interference takes the form of a complex of limitations in addition to the accepted controls of our society upon all individuals.

A White or a Negro in the South learns the behavior demanded of him in his color-caste position chiefly by experiencing (or anticipating) pain or deprivation if he attempts to reach a goal by any other route than that prescribed by the society. To the Negro child, as our cases show, caste presents a group of arbitrary behavioral demands which he is compelled to learn. He is forced into these learning dilemmas both by his Negro parents and by the white children and adults with whom he has contacts. When the colored child is learning to behave as a lower-caste person, he is finding a method of acting within the frustrating taboos of caste so that he may reach those limited and substitute goals which the society does allow him.

Both the white and the colored child acquire their caste training in two types of relationships: in their family and from non-family members of their own caste, and in contacts with members of the other caste. At the age of five or six, the child learns that he must sit only with his fellow caste members on the bus or in the theater, and that he must attend schools which have only children and teachers of his own caste. Within his family, he receives instruction in the behavior required toward members of the other caste. As he becomes adoles-

cent, both the definiteness and the parental reinforcements of this instruction increase greatly, for it is then that the occupational and other taboos become matters of urgency.

In general, the Negro child learns from Whites that he can not be a member of their economic, social or educational groups. He also learns that he must not be aggressive toward them, but must dramatize his subordinate position by various explicit forms of deference. From his own family, he usually learns that Whites are extremely powerful and dangerous and that he must, therefore, not display aggression toward them. If even the powerful adult can not resist Whites, what can the child hope to gain by attack? He is taught, however, that within the bounds of his caste position he may adopt substitute modes of aggression toward Whites. For example, certain well-disguised forms of getting even, such as sabotage in his work for Whites (slowness, lack of punctuality, clumsiness), and the use of flattery, humor, secretiveness, ignorance and other behavior for outwitting Whites, are learned at an early age

The actual caste behavior of the parents themselves appears to be more important in determining the child's type of accommodation to Whites than does verbal instruction on this point As in other forms of learning by identifying with a person who has already learned, the child discovers what behavior will be punished and what rewarded by observing his parents and listening to their accounts of experiences with Whites

The child whose parents are of unlike class origins usually receives one type of caste instruction from his mother and a different type from his father. For example, if the father is of lower-class origin, he will almost certainly tell his son to submit to all White demands unless he is threatened with violence, in which case he should fight. If the mother has been trained in a middle-class family, she will probably teach the son to avoid Whites and not to fight them under any circumstances. A child who lives in such a family, or in a family where one parent has been reared in the South and the other in the North, is placed in a continual and almost insoluble dilemma, which may be expected to increase his anxiety and maladaptive tendencies as compared with the child whose parents have the same class and sectional origin.

The second type of conflict in the caste training of the Negro adolescent is especially prevalent in cities. It is the dilemma of the ambitious child who is beginning to associate with, and to assume the behavior of, a class which is above that of his parents The first step in such a rise in their class status for the mass of lower-class colored children in Natchez or New Orleans is to finish a high school course. In this process of educational advancement, the colored adolescent faces a conflict between the caste instruction and example given him by his teachers, who are usually middle class and by his parents, who are lower class. The middle-class teacher not only gives the colored child instruction in skills associated with the White caste, but he has gained professional status. Such differences in caste training apply both to etiquette and to the choice of an occupation.

In this situation, the Negro child usually identifies with his teachers: that is, he rejects the training and example of his lower-class parents who must be deferential to their white employers and who must accept domestic or manual labor. When he completes high school, such an ambitious child faces the basic caste restriction against skilled and clerical work for Negroes. In order to achieve a middle-class position, he must therefore either go on to a higher school and become a teacher or he must obtain a position as a clerk in some Negro bus-

iness. If he is unsuccessful and has to accept a menial or domestic job under a white supervisor, he experiences a basic frustration upon both color-caste and class grounds.

This analysis of the personality formation of Negro children in the South bears out the theory that personality is not inherited; it is learned. The fact that personality, disposition, and character form a learned pattern of behavior means that there can be no racial "inheritance" of personality. People are not born with their personalities; they acquire them by experiences in a social environment. Finally, it is evident that there are no racial types of personality because within each race there are several social strata, each of which has a different culture, and each of which teaches different kinds of behavior and psychological goals to its members

If one wishes to know what one may expect of a man, one needs to know in what kind of a culture, not in what race, he has been reared. More than anything else about a man or a woman, however, one needs to know what his loves, his fears, his hates are, and what he considers valuable in life, and valuable beyond life. Certainly there is not one of us who has not met a man of another group or race who was congenial, or brave, or honest, or self-sacrificing or honorable. All of us also have met members of our own and of other groups, or races, who were cowards, or imposters, or murderers at heart

If one wishes to know whether one may depend upon a man, or trust him behind one's back, or with one's children, or stand shoulder to shoulder with him against a common enemy, one needs to know his individual nature, not his race. The troubles of this chaotic world of international anarchy in which we live are not made by this race nor by that race; they are made by men who hate, and lust for blood and revenge, by men who envy, and crave for personal dominance and aggrandizement. The greatest possible benefit to mankind which one can conceive would be the practice of dividing men into groups according to whether they wished to kill, to dominate and to plunder, or whether they wished to cooperate, to share, to advance human development one step beyond the jungle stage in which we now live—to be men of good will. Such a division of mankind would bring together men of every color and race.

THE AGE OF FLOWERING PLANTS

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If you were to ask the president of almost any of the numerous garden clubs in the United States, "What is a flowering plant?" she would look both surprised and puzzled. She might even feel sorry for you for asking such a silly question. If you were tactfully to pursue the subject into the question of the ancestry of the flowering plants, it might be admitted that of course plants had ancestors. So what? Plant genealogy has not the personal appeal of human genealogy, nor is it so dramatic as the ancestry of the horse, elephant, rhinocerous or camel There is nothing in the ancestry of any plant comparable to that of the giant wolves or saber-tooth tigers of the southern California asphalt deposits

Most educated people have some concept of the noble races of animals that have moved across the world stage during the millions of years of the Age of Mammals. But students of fossil plants have had many handicaps, their subject-matter is much less complete and confessedly less exciting. Sporadically a "Save the Redwoods League" disseminates information about sequoia genealogy, and the history of the Oriental maidenhair tree, or ginkgo, has been repeatedly written, but for the rest little has been written and still less has become a part of general consciousness. Moreover, paleobotany has had no patrons, like the great oil company that has sponsored the discovery and restoration of the dinosaurs, or like the late W. C. Whitney, an admirer of race horses, who gave princely sums for the study of the geological history of horses. Nor have our great museums fostered studies or exhibits of fossil plants. They have halls of mammals or reptiles, but the fossil plants are in the attic or cellar or storage warehouse. And there is yet to be organized an expedition to Patagonia to collect fossil plants, or one to the West Indies or Central America, which might throw much light on the subject of former land connections in that important region

But let us get back to the lowest common denominator of general knowledge about plants. We can divide the Vegetable Kingdom into two great groups, which we call, for the sake of simplicity, seed plants and spore plants, roughly comparable to, and as a matter of fact more exact than, the division of the Animal Kingdom into vertebrate and invertebrate animals. The seed plants may again be divided into flowering plants and gymnosperms (conifers), or those that organize what we call flowers and produce seeds in closed fruits and those that have naked seeds in cones, like the pines and sequoias. The spore plants are less complex, and all their living members—on land at least—are relatively small, although some of their ancestors in the ancient coal period were far from simple and were of gigantic size.

The spore plants are relatively unknown to most people; the only group of them with which the average plant lover has any familiarity is the fern, and this familiarity is not too precise, since neither dealers nor gardeners hesitate to include under ferns the asparagus-fern, which is not a fern but a flowering plant In the East we call a very handsome shrub the sweet-fern, although it is really a myrica, another flowering plant. Nearly everybody knows the names of some of the other groups of spore plants,

such as mosses, seaweeds and fungi, but they would be hard put to it to explain why a clubmoss is not a moss or what the fundamental difference is between a mushroom or toadstool and an alga.

The accompanying greatly simplified outline will enable one to visualize the whole Plant Kingdom, and it will also make clear some of the terms for concepts that have been used by those who have discussed some of the larger and more theoretical problems of the evolution of plants on the land.

there is what is called a pistil, a style that leads down to an ovary in which the ovules are fertilized and develop into seeds. Surrounding the pistil are few or many stamens, *i.e.*, slender stalks with sac-like expansions at their tips in which the pollen is formed. Pistils and stamens are the really essential parts for the reproduction of the plant. Outside these is usually one or more series of often brightly colored organs known as petals and sepals. These organs are unessential for reproduction, except as they

Seed-plants (phanerogams)	Flowering plants (angiosperms)	Dicotyledons Monocotyledons	Embryophyta	Vascular plants
	Gymnosperms	Conifers Cycads Ginkgos Cordaites Seed ferns		
Spore-plants (cryptogams)	Ferns (pteridophyta) Equisetums (arthrophyta) Clubmosses (leipidophyta)	Archegoniates		
	Mosses and liverworts (bryophyta)			
	Algae, fungi, and bacteria		Thallophyta	

But to confine our attention to the flowering plants, we have to ask ourselves not only what a flower is but also why flowering plants are important. The definition or at least the recognition of a flower would be no problem to an amateur gardener or to a honey-bee, but morphological botanists have expended more thought upon this botanical problem than on almost any other and have used considerable ink in trying to frame the correct definition. It all started in Goethe's time with a certain ideal of a flower and a comparison of all others with the ideal and perfect concept. Schemes of classification and keys for identification have been almost wholly based on flower structure.

Nearly everybody knows the parts of an ordinary flower; for example, that of a cherry or a buttercup. In the center

have been adapted for attracting various kinds of insects that visit them and carry pollen from flower to flower and thus effect cross-pollination or cross-fertilization.

Now we come to the difficulty of framing a definition. Is the flower to include merely the essential stamens and ovary? If so, then many plants that are not related to the flowering plants have flowers. Shall the criterion be the colored parts? If so, many flowering plants do not have flowers. Are the so-called double monstrosities, such as roses, altheas and tulips we cultivate, flowers, since most of them lack the essential parts and do not form seeds? What shall we say of poinsettias, snow-on-the-mountain, hydrangeas and the flowering dogwood in which the bright parts are not sepals or petals but

proliferated bud scales, colored bracts or leaves? And then again we have a host of so-called catkin-bearing plants like the oaks, poplars and willows, which have the essential organs but lack colored floral envelopes. Our only recourse is to fall back on common sense and admit that we can not frame an all inclusive definition.

From the beginnings of modern botany the flowering plants have been divided into two great groups. These are the monocotyledons, once mistakenly thought to be the most ancient, and including lilies, palms, orchids, and grasses; and the dicotyledons, including oaks and maples and the majority of garden plants The names embody the facts that there is one seed leaf (cotyledon) in the first and that there are two in the second; they differ in a number of other and mostly unimportant particulars in stem, leaf and arrangement of flower parts There has been much discussion as to whether both groups are descended from a common ancestral stock, which is the oldest, and whether all within the group are blood relatives. It would take us too far into details to develop this genealogy, important as it is.

The flowering plants are easily the dominant plants of the modern world, the most adaptable to all sorts of environments. They exhibit almost infinite variety and are what we should call highly successful. Compared to them the other great group of seed plants—the conifers—are underprivileged and appear adapted to a hard life. Hundreds of thousands of species have been described. Although much more ancient than the angiosperms, the inability of the gymnosperms to compete for a place in the sun indicates neither that they suffered a misspent youth nor that living conditions were harsher in the past. They can not compete with the flowering plants simply because their organization is less efficient. Flowering plants have a better circulatory or vascular system, directly to be correlated with a greater display of assimilating surface (green foliage) Most conifers have more or less xerophytic foliage; that is, their leaves are for the most part reduced to needles and their cuticles are more impervious to gases. Flowering plants have their tissues better ventilated; most of them grow faster; they have better devices for the protection, fertilization and nourishment of their ovules, and above all they have highly developed methods for maturing and disseminating their seeds, in which they pack miniature seedlings with foodstuff to give them a start in life.

Volumes have been written on the various means perfected by plants for scattering their seeds These range from such simple devices as wings (or parachutes) to more mechanical means, such as that found in the witch hazel, which by a process of drying and contraction of the seed walls ejects the hard seeds with as much efficiency as a small boy can shoot a slippery orange seed by squeezing it between his fingers. Or they may develop a torsion in some part of the fruit, which shoots away the seeds, as, for example, in the wild geranium known as cranesbill, or in the little balsam known as touch-me-not.

Hundreds of other plants have their fruits in the form of hold-fast-burs, stickseeds, or beggar-lice, which accumulate on your clothes during an autumn walk or which stick to the feathers or fur of birds and mammals and are thus disseminated.

Small seeds of water plants often dry in the mud pellets on the feet of water birds and are carried long distances to new wet places. Or seeds may develop so resistant a seed coat as to pass unharmed through the alimentary canal. Especially is this true of hosts of small fleshy fruits like cherries, grapes, mulberries and brambles, whose seeds are

unharmed by their digestive journey but may be dropped miles away, with an appropriate amount of fertilizer. Many stream-border plants are equipped with special devices for being carried intact for long distances, like the European water chestnut (*Trapa* or caltrop) introduced in recent years into North America. Most specialized for floating are forms like the snuffbox bean, which retains its vitality and is unharmed for weeks in ocean currents. There are quite a number of West Indian forms that journey regularly to Europe via the Gulf Stream

Nut-bearing trees like the walnuts and hickories trust to luck that their fruit will be carried away and buried by squirrels and then forgotten.

The importance of the fruits and seeds of the flowering plants to the warm-blooded animals and to man rests on this habit of storing foodstuffs in seeds and fruits, and to a less extent in roots or tubers Some of them, notably the cereals, in this way store as much as one-third of the dry weight of the whole plant.

Mammals are known in the geological record for millions of years since the period that geologists call the Triassic. Through all this time until late Cretaceous they were few and small. Then followed the time when modern-looking flowering plants appear in the geological record, and the mammals underwent that marvelous evolution that makes the Age of Mammals the quite proper appellation for the latest of the geological eras

From the quite human point of view man was the culmination of the evolution of the mammals. Even as good a churchman as Linnaeus classed man and the apes in the order called Primates. Anthropologists are agreed, however, that primitive man could not have advanced beyond the hunting and fishing state of culture had there been no flowering plants—the foundation of agriculture. Even that less advanced state known as nomadism was dependent on flocks and herds, which in turn depended on pasture, which again is furnished by the flowering plants—gregarious plants like the grasses yielding food for the gregarious animals such as sheep, cattle, yaks and camels.

We get a picture of primitive agriculture in the deposits of the lake dwellings of central Europe—the Robenhausian culture—about 10,000 years ago. Agriculture permitted permanent dwellings, increase in population, domestication of some of the wild animals and development of pottery (primarily for storage), and these inevitably resulted in social customs that gradually crystallized in codes. The final result—what we call civilization—would obviously not have been possible had it not been for the evolution of the flowering plants and the great increase in food that their special adaptations for seed production permitted

The problem of the origin of the flowering plants has always interested scientists. Nearly a century ago Charles Darwin wrote to his eminent countryman, Sir Joseph D Hooker, complaining about the total lack of information on this subject, and we are little better off at the present time. There are two methods of approaching the problem. One is by way of the comparative morphology of existing plants, but this has not proved particularly fruitful, first because the modern plant is a product of ages of modification scarcely realizable, especially against the background of geological time as we now evaluate it, and further because we have many compelling traditions, derived from the Pentateuchal concepts of a world only a few thousand years old. In such a brief span as the latter it would be natural to suppose that all plants were rather closely related and that the more complex were

genetically related to their simpler contemporaries. It has become increasingly clear that in those survivors of ancient lines constituting the existing floras the actual relationships are collateral and that our genealogical tree is not a tree at all with a central stock and many branches, but really a bunch of parallel or diverging stocks.

The second method of approach to the problem of the ancestors of the flowering plants is by investigating their fossil history; that is, by studying the actual documents of evolution preserved in the rocks and in the order of their succession. This would be fine except for the fact that this record is very fragmentary —not only are the actual fossil plants in fragments but also the record itself is distressingly incomplete It can be truly said of the flowering plants, as well as of all the other major groups of plants, that the really remarkable discoveries of paleobotanists of the past thirty years instead of closing any of the gaps or furnishing us with so-called "missing links" have raised new problems, and we are quite as far from our goal as ever. It has also become clear that the ancestral lines go back much farther into the past without converging, and we are finally lost in a conflicting plexus of structures and a corresponding plexus of ideas.

Before discussing the geological history of the flowering plants it is necessary to say something about time. Bishop Ussher calculated that the earth was created in 4004 B.C., and this has been the orthodox view since the seventeenth century. Neither geologists nor students of evolution could reconcile their discoveries with so youthful a world, and in the past hundred years or so there has been a great variety of attempts to get more precise values. There is no need to enumerate these methods—all have proved to contain too many assumptions and too incomplete data. The currently fashionable method is based on the atomic state of certain radioactive minerals found in the rocks. It seems better to us and probably is better. At any rate it will give the perspective we seek.

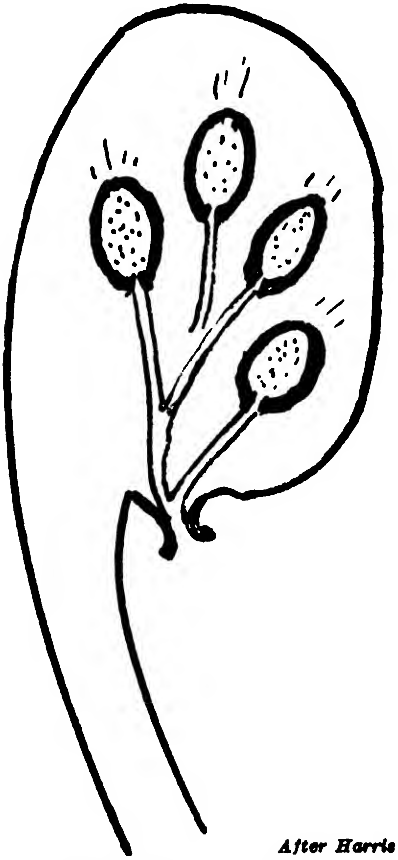
I am taking for my purpose the figures in Bulletin 769 of the U. S. Geological Survey published in 1925. These are not the latest or best, as the subject is actively being studied by chemists, physicists and geologists, but this is not serious, since we are only concerned with relativity and round numbers. We may then present the following time table, which covers the younger part of the geological column during which the flowering plants are supposed to have evolved:

Cenozoic, or Modern Era (55 to 65 million years)	Pleistocene	1 to 1½ million years
	Pliocene	6 to 7½ million
	Miocene	12 to 14 million
	Oligocene	16 million
	Eocene	20 to 36 million
Mesozoic, or Medieval Era (135 to 175 million years)	Cretaceous	65 to 85 million
	Jurassic	35 to 45 million
	Triassic	35 to 45 million

The situation with respect to the geological record of the flowering plants is about as follows: Very modern-looking leaves are abundant in the record back to a little beyond mid-Cretaceous times, which carries us back 85 to 105 million years. Many of these leaves, like those of sassafras and tulip poplar, have sufficiently individualistic characters to be easily recognizable Others can not be so positively determined. The point is that the earliest of these leaves show no indications of being different from or more primitive than what we would find in a modern bayou or pond or forest litter. The only difference is that there is a greater similarity between the fossils found in central Europe, Patagonia or North America than we would find today. In other words, the geographical

distribution was very different and more general, *i.e.*, extensive.

Much the same conclusion is to be drawn from petrified wood, several different stems having been discovered in slightly earlier deposits—deposits that geologists refer to as the Aptian stage, called by the English the Lower Greensand. These woods show the same mod-



After Harris

FRUIT OF CAYTONIA

A DIAGRAMMATIC SECTION SHOWING THE SEEDS IN THE FLESH AND CONNECTED WITH THE EXTERIOR BY OPEN MICROPYLAR CANALS.

ern structural organization and can be referred without difficulty to modern families. A petrified flower discovered in the Upper Cretaceous of Japan is unmistakably referred to the lily family.

Obviously these earlier fossils of angiosperms are in no sense primitive or ancestral, and we are no nearer a solution than was Darwin or Hooker. There are two escapes from our dilemma: We can assume either that the real founders of the dynasty were never preserved as fossils, perhaps because they dwelt far removed from places suitable for their preservation, or that if they were buried and preserved they have not yet been discovered. What seems more probable is that these ancestors were so protean that they have not been recognized as ancestors. That this may eventually be the answer is suggested by some interesting discoveries in the Jurassic of Yorkshire, Sardinia and East Greenland. These discoveries comprise a constant association of foliage, long known as impressions called *Sagenopteris* and once thought to be related to the water ferns, with seeds that have been christened *Caytonia* and *Gristhorpia* and with stamen-like bodies (*Antholithus*).

These fruits are fleshy and in two rows on a shoot. Several seeds are imbedded in the flesh and at first sight it seems to be a fruit of a flowering plant. The difficulty is that the tiny seeds have open ends like the seeds of gymnosperms, and Harris has found pollen in these open ends and believes these were connected with the "stigma" by canals. In all known flowering plants pollen falls on the stigma where it germinates, and the developing pollen tube carries the sperms to the completely enclosed ovules. The difficulties of correctly interpreting these not-too-clear petrified tissues caution against too great an enthusiasm, but if the interpretations are confirmed by additional discoveries they will throw our ideas of classification into confusion and give us quite new ideas about the adaptive function of pollen tubes and shed a long-awaited light on our problem.

If the Harris interpretation is the true one, and it seems to be convincing, then *Caytonia* opens a tremendous vista of angiosperm evolution, the open seeds being considered as retreating within fleshy fruits but still connected with the

exterior by open canals, down which the pollen grains found their way to the ovules It throws new light on the evolution of pollen tubes. The situation observed in the existing cycads and in gingko acquires a new meaning as illustrating a stage in the formation and adaptation of pollen tubes In this stage the pollen freely enters the micropyle, where it germinates as a sort of "hold fast" while the pollen is growing and developing the ciliated sperms, which are then discharged in the vicinity of the archegonia This stage can now be regarded as an intermediate one

The later stages would be regarded as steps leading to the complete closure of the micropyle and the development of angiospermy in the modern manner This would seem highly suggestive, although it would still leave the controversy open as to which group or groups of gymnosperms constituted the true ancestor of the angiosperms

In so far as the later geological history of the flowering plants is concerned it can be briefly summarized We find them assuming a leading role in land vegetation during the Upper Cretaceous There appears to have been a great modernization at the dawn of the Tertiary, perhaps more apparent than real. The early Tertiary appears to have been a time of optimum climates. Equatorial types spread long distances into both the North and South Temperate Zones, and Temperate types penetrated far into the polar regions. The subject is too complicated to be adequately discussed but appears to be partially explained by continental submergence and widespread oceanic climates, perhaps accompanied by the melting of polar ice caps.

There is nothing in the later Tertiary history except shifts in the distribution and the gradual shifting of warmer types toward the equator. Then, with the maximum elevation of the continents to at least their present relative proportions, there was ushered in the Pleistocene glacial period. This did lots of things to the plants. The floras of all the northern continents had previously been essentially similar. Europe had its magnolias, hickories, tulip trees and sassafras, along with gingko and many others. After the ice was gone Europe emerged with a depauperate flora (owing to geographic and topographic reasons), and two great Tertiary forest reserves remained—one in southeastern North America and the other in eastern Asia The bald cypress and the tulip tree and a host of others no longer flourished along the Columbia River The sequoia and many others became extinct in the Great Basin as well as elsewhere in the world but fortunately survived in the redwood region and the fog belt of the Sierra Nevada.

Not only was the Pleistocene glaciation responsible for a vast amount of rearrangement in the distribution of plants, but it also mixed soils, altered drainage patterns, blotted out vast areas and when melted opened these areas to recolonization All this had evolutionary effects, and there is considerable evidence for the belief that many of our large herbaceous families, such as the cresses, pinks, mints and composites, had their chief expansion in interglacial and postglacial times I do not mean to imply that these families were absent earlier, but they were much more insignificant members of plant society then than they are now.

This brings us to the end of our story and to the world as we see it (clothed with verdure, if not in its right mind)—to the lush tropical jungles of the equatorial zone, the vernal and autumnal brilliance of our own latitudes, and the tundras of the north with their dwarf willows and birches. We end our journey where the plant morphologists and taxonomists start, but I believe ours is the truer picture, even though it has not led us to a botanical Nirvana.

BOOKS ON SCIENCE

DOCTORS OF THE MIND*

WHAT stands out in this book is the comprehensive and thorough manner in which the subject is discussed. Bibliographical research studies, visits to laboratories and to psychiatric institutions, and interviews with authorities in their respective fields provided the author with an enviable amount of scientific material This is conveyed to the reader (probably intended mainly for the lay reader) intelligibly and entertainingly.

The story begins with a survey of the origin and development of the human brain *Homo sapiens* is reminded, in a language that should not hurt his pride, that his nervous system has gradually evolved from such insignificant things as the sea anemone, the jelly fish, the worm, the frog—up to that more respectable being—the ape.

Kohler's experiments with chimpanzees on the Canary Islands are recounted vividly and colorfully, yet without doing injustice to the observed facts. The reader's curiosity about the human-like behavior of the chimpanzee is soon satisfied by the author's incursion into the science of paleontology to show, "a steady progression from small brains with low intelligence to bigger brains with better intelligence—from ape-like to man-like brains" Then the reader is initiated into the intricate investigations of Broca who discovered that certain areas in the brain control the understanding of either uttered or written words. Broca's studies have paved the way for the search for brain centers connected with other functions.

The story of mesmerism, hypnosis, the origin of the concept of the subconscious, and of psychotherapeutic methods (Mesmer, Braid, Bernheim, Liebeault, Janet, Charcot, Dubois, Dejerine) offers fascinating reading. Rejected by the medical profession and nonmedical scientific workers, Mesmer remained nevertheless true to the general precepts of the official science in insisting on his theory of "animal magnetism" to explain what were obviously mental influences. Without recognizing it, Mesmer was the first to demonstrate the therapeutic value of suggestion and good rapport between patient and physician

Kraepelin's teaching that mental diseases are essentially physiological or organic is discussed in the light of available knowledge on the anatomy and physiology of the brain (Broca, Hughlings Jackson) and the chemistry of the glands of internal secretion (Abel).

The story of the advent of psychoanalysis (Breuer, Freud), of the differences between Freud, Jung and Adler, with Adler's individual psychology, epitomizes the fundamental issues in the concepts of the respective schools This chapter brings forward the controversies between the so-called physiological and psychological psychiatrists and their common aspiration to win "victory in the war on mental disorders"

"Fighting Fire with Fire," "I Saw a Resurrection," "The Insulin Hour," "And the Devils Departed," "Shocked into Their Senses"—these are the spectacular or scare-titles of chapters recounting the advent of the malaria treatment (Wagner-Jauregg), insulin therapy (Sakel), pharmacologic and electric convulsive therapy (Meduna; Cerletti and Bini). It occurs to the reviewer that the story told in these chapters is informative and interesting enough to hold the attention of the reader without resorting to the expediency of arousing emotions with catchwords. Equally factual is the tale of various other up-to-date therapeutic procedures.

The discussion of the concepts of organically minded, psychologically

* *Doctors of the Mind, the Story of Psychiatry.* Marie Beynon Ray. Illustrated. 335 pp. $3 75. 1942. Little, Brown and Company.

minded and middle-of-the-road psychiatrists relies largely, if not exclusively, on interviews. In the main, the author succeeds in conveying to the reader the different viewpoints regarding the nature of mental disorders and their treatment. There are, however, serious flaws for which, perhaps, those who were interviewed are more responsible than the interviewer.

This book was read by the reviewer with mixed feelings: first and foremost, an appreciation of the writer's very serious delving into a great variety of scientific disciplines and of the lucid presentation of each of the many topics At the same time, the highly dramatic tone of the presentation, which appears to be kept up intentionally throughout the entire book, gives the impression of melodrama. The reviewer is satisfied, however, that the melodramatic element does not obscure the drama of psychiatry

S KATZENELBOGEN

THE LIFE WORK OF G. E. MOORE*

THIS work is a collection of nineteen descriptive and critical essays dealing with the philosophy of one of the main leaders in the revival of philosophic realism since the beginning of this century Moore's views on ethics and on method are also discussed by some of the contributors. A reply by Moore to his critics closes the book.

An opening autobiographical sketch affords interesting and, sometimes, vivid glimpses of the intense philosophic activity of at least one little group in Cambridge University during the nineties In 1903, when the writer was thirty years old, his first important paper—"The Refutation of Idealism"—was published in *Mind*. From that time to his visit to the United States in October, 1940, Moore has written one paper after another dealing with different aspects of the problem of perception. His editorship of *Mind* since 1921 has undoubtedly enhanced his prestige and the "carry" of his views.

The essays in the present work have titles which indicate the points in Moore's theory where the critics felt impelled to comment or criticism. Thus, O K Bouwsma discusses Moore's theory of sense-data; C J. Ducasse examines his early *Mind* article of 1903; Paul Marhenke considers Moore's analysis of sense perception; C A. Mace takes up the question of how we know that material things exist; and Arthur E Murphy writes on Moore's defense of common sense Another essay, called "Moore's Paradox," by Morris Lazerowitz, with quiet, sustained and controlled humor, glances at the ways in which a professed idealist contradicts his assertions in his acts and utterances. His explanation, however, of why and how an intelligent and sincere man can profess idealism, does not commend itself to Mr Moore and will probably commend itself to very few readers.

It should be remarked that *The Philosophy of G. E. Moore* does not contain anything like a symposium on idealism versus realism; possibly for this reason only one contributor notes (and that merely in passing) that what Moore has had so large a hand in doing, has been a revival of the Scottish Philosophy, the philosophy, that is, of Thomas Reid, Sir William Hamilton and James M'Cosh of Princeton. From another standpoint it has been said of Moore that he "put a strong curb upon the exuberant speculations of Hegelianism " But however it be put, his influence has been immense in vindicating sobriety in dealing with the problem of the mind's grasp on the world.

But what definite solutions has Moore attained? Dr. Rudolf Metz, in "A Hundred Years of British Philosophy," says: "Though we may call Moore the greatest,

* *The Philosophy of G. E. Moore.* Paul Arthur Schilpp, editor. Illustrated. Vol. IV in "The Library of Living Philosophers," xvi + 717 pp. 1942. $4.00. Northwestern University.

acutest and most skilful questioner of modern philosophy, we must add that he is an extremely weak and unsatisfying answerer." Of the truth of the eulogistic portion of this comment there can be hardly a doubt, indeed, Moore's ability to pounce on a contradiction, especially when latent; to pull out nonsense from what some unfortunate writer had deemed to be a massive display of intellect, appears unsurpassed in severe philosophic literature. One recalls the Duke of Wellington's comment on Napoleon: that never was there an opponent before whom it was more dangerous to make a false move

But what of the rest of Dr Metz' verdict? Here is Moore's own comment in his "Reply". "I think Dr Metz was quite right in saying that I am an 'unsatisfactory answerer ' I think it is a just charge against me that I have been able to solve so few of the problems I wished to solve I think probably the reason is sheer lack of ability and partly that I have not gone about the business of trying to solve them in the right way "

If Moore has not the ability required, the likelihood that anyone else has is not very high, but perhaps his second suggestion hits the nail on the head The problem of perception first attained what might be called scientific formulation in the disputes between the Stoics and the Academies of Athens [1] In this debate several assumptions, obviously regarded as self-evident, were made by both parties; and these assumptions have not only come down the ages but they seem to be taken up, as a matter of course, by all who have dealt with the question To deny them would seem more paradoxical than idealism; yet perhaps it is just these tacit postulates that have deflected the stream of thought concerned with the problem.

FREDERIC DREW BOND

[1] A little treatise dealing with this matter has come down to us from antiquity

FOOD POISONING*

"IT was something I ate," is the self-diagnostic explanation offered by all too many people for a pain anywhere between the base of their neck and their hips. "Indigestion" is such a convenient catch-all and so innocuous in implying just a temporary little upset Food poisoning is classed as one of the commonest and least dangerous of maladies by the man on the street He is wrong on both counts Just how frequent true food poisoning of one sort or another is, we do not know Most individual attacks and many small family outbreaks go wholly unreported and are never seen by physicians On the other hand, when a number of people are simultaneously affected, particularly following some public banquet, the newspaper scareheads make much ado, politically minded reformers belay the local health departments with charges of gross laxity and sometimes the furor of excitement is carried over into legal suits for damages To ignore food poisoning as insignificant is stupid, to wax passionate and belligerent over every outbreak is equally illogical Somewhere between these extremes lies the truth

Just now a new, authoritative, accurate and clearly presented book on food poisoning is particularly timely War has brought about profoundly significant changes in our food supply, qualitative as well as quantitative changes War manpower shortages have affected food processing, packing and preserving plants A recent newspaper item mentions the delay in canning tomatoes because of inadequate help at the canneries. Hotels, restaurants and institutions cry aloud for kitchen help. What help is available is usually untrained, incompetent and wholly unconscious of the simplest rudiments of sanitation and hygiene. Victory gardens and amateur home canning in glass jars invite spoilage of food Commercially canned

* *Food Poisoning* G. M Dack 138 pp. \$2.00. 1943. University of Chicago Press.

foods always have been and always will be infinitely safer and usually more nutritious than "homemade" fruit or vegetables. Inadequate equipment, guesswork, lack of skill and lack of practical knowledge on the part of the patriotic amateur preserving for the first time are in sharp contrast to the adequate equipment, scientific control of temperature and pressure in sterilization, and sense of serious responsibility found in commercial canning practices. This coming winter, when the amateurs begin to consume what the insects and summer appetites have left of the Victory garden crops, a considerable increase in food poisoning is to be expected

Professor Dack includes under the broad term of food poisoning those acute, explosive illnesses generally characterized by gastro-intestinal upsets due to *ingestion* of an offending agent Among such agents are chemicals, poisonous plants and animals, bacteria and their toxic products, protozoa and helminths The major emphasis is upon those disorders due to bacteria and their toxins

Though the volume is small and is not illustrated, it is tightly packed with sound information Differentiation of the various types of intoxication is clear and concise Particularly well presented is the valuable material on botulism, the most dangerous and insidious of all forms of food poisoning. The text is liberally documented with references The volume is not a textbook, nor is it a highly technical discussion suitable only for digestion by bacteriologists or physicians It should prove to be of considerable value to all those concerned with food poisoning And such are many. As collateral reading in courses in medicine and home economics and for those involved in the preservation, preparation and handling of food, it will reveal much necessary information. City and state public health officers, the quartermasters corps of our armed forces and industrial food workers can all profit by study of this volume. Specific cases and experimental evidence are cited to illustrate each type of disorder Of special value are the discussions of methods effective in establishing correct diagnoses in outbreaks of food poisoning The book is heartily recommended. All those who read it will learn much.

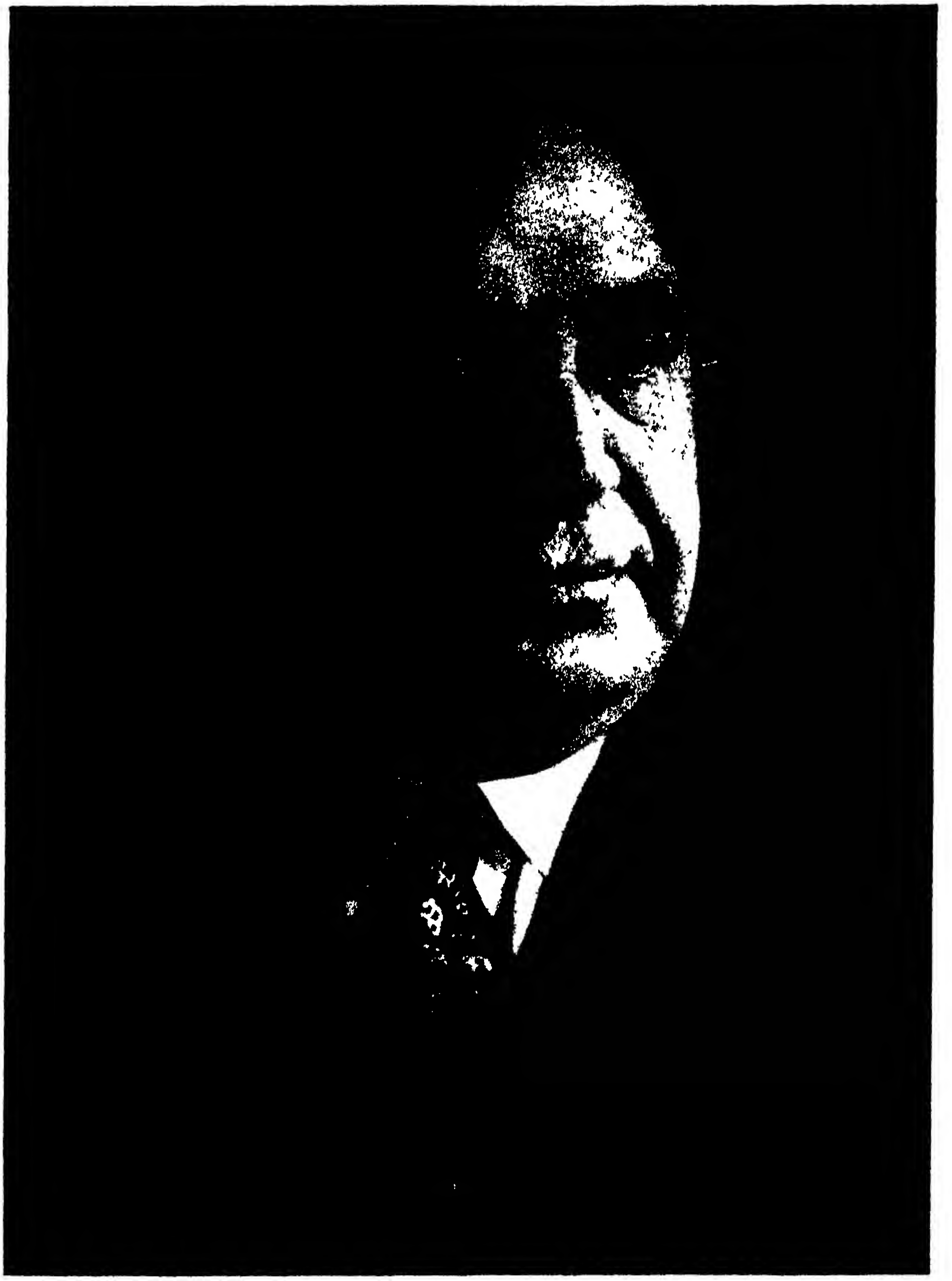
EDWARD J. STIEGLITZ

HOME CHEMISTRY*

FOR adults who learned no chemistry in high school and now need to know something about it, this is a good rudimentary textbook It is simple, attractive, well illustrated and—best of all—it gives detailed instructions for scores of simple, revealing chemical experiments that can be done with household or drugstore materials It is didactic with regard to all theoretical matters, such as atoms and molecules and omits entirely such technicalities as formulas and equations But it does convey a modicum of the basic concepts and of scientific reasoning from experiment. Most of the book is given to rapid-fire but skilful and sound explanations of common materials of the home and farm Its scope is no more than that of the first half-dozen chapters of an elementary textbook air, water, salt, carbon, metals, carbohydrates and cellulose. There is also a descriptive chapter on plastics but the author wisely does not venture into chemicals as complicated as sulfuric acid nor into nutrition, vitamins, dyes and such topics for which the reader is not prepared His book would make a good companion-piece for a boy's "chemistry set"

GERALD WENDT

* *Getting Acquainted with Chemistry.* Alfred Morgan. Illustrated 271 pp $2.50. October, 1942 D Appleton-Century Company.



FRANK SCHLESINGER
1871–1943

THE PROGRESS OF SCIENCE

FRANK SCHLESINGER, 1871–1943

Dr Frank Schlesinger's distinguished career came to a close on July 10, 1943, when he died at the age of seventy-two in his home at Lyme, Connecticut. His death came after only two years of retirement from active academic life.

His principal field of activity was that of photographic astrometry, in which he left a record of impressive accomplishments. He was attracted to this branch of astronomy when he was studying for his doctor's degree at Columbia University (1894–1898). Under the directorship of John K. Rees, the Observatory of Columbia University had undertaken the measurement of numerous photographic plates of Rutherford's collection The results of these measurements established the importance of the photographic method of astrometry It became Schlesinger's ambition to apply it to the determination of stellar distances with a long-focus telescope. In 1903 the Carnegie Institution of Washington made it possible for him to spend two years at the Yerkes Observatory During these years he developed the modern method of determining trigonometric parallaxes. As director of the Allegheny Observatory of the University of Pittsburgh (1905–1920) and as director of the Yale University Observatory (1920–1941) he continued the work begun at the Yerkes Observatory A most interesting circumstance is that he began his directorship of both observatories with plans for the construction of a new type of telescope particularly suitable for parallax work For the Allegheny Observatory he designed the thirty-inch Thaw refractor; for the Yale Observatory the twenty-six-inch telescope that was erected at the Observatory's Southern Station in Johannesburg, South Africa. Both are of the photographic type. The decision in favor of telescopes adjusted to photographic light was made because their efficiency is so much greater than that of visual telescopes used for photographic work.

The importance of the trigonometric parallax is two-fold It furnishes accurate distances of the nearer stars and, therefore, the distribution of stars in the region of galactic system in the sun's neighborhood In addition it furnishes a calibration of less direct methods that are used for stars at such great distances that the trigonometric method fails This calibration requires the carrying out of a systematic program of parallax determinations of the brighter stars without selection on the basis of their distances It is typical of Schlesinger's service to Astronomy that he concentrated upon this latter field. The *General Catalogue of Stellar Parallaxes*, editions of which appeared in 1925 and 1935, compiled under Schlesinger's direction, shows the enormous progress made since his pioneer work at the Yerkes Observatory

A second large undertaking in astrometry was the use of the wide-angle camera for the determination of star positions by photography. Here again, high accuracy and efficiency were achieved. The original work was done at the Allegheny Observatory with a camera designed by Hastings and with plates covering five by five degrees. With cameras designed by Dr. F E Ross the area of the sky photographed on a single plate was increased to eleven by eleven degrees. This was the size of the plates adopted after considerable experimentation with even larger plates. The success of the work in this field led to an ambitious program that covered one half of the entire sky, and that, when completed, will give positions and proper motions of some 140,000 stars. During the last five years of his directorship of Yale Observatory this program became the main effort of the observatory. He

saw to it before his retirement that all of the measurements were completed, and that the computations were far advanced. At the time of his death about sixty per cent of the results had appeared in printed catalogues He had the satisfaction of knowing that every effort was being made to carry the entire program to an early completion under the guidance of Dr Ida Barney who had been his chief lieutenant in this program from the start

The results of the two large astrometric programs constitute the main legacy of Schlesinger's activity as astronomer Both were conceived as large routine programs that were undertaken after patient experimentation in which numerous difficulties had to receive minute attention The accounts of the experimental work and the precepts for the final procedure have become classics of astrometric research It has been frequently stated that his colleagues working on related problems turned to Schlesinger's papers whenever they encountered a real obstacle to learn what he would have done in similar circumstances

It is, no doubt, a very fortunate circumstance for a research man, if he can design and build the instruments that he needs for the specific projects that he wishes to undertake Less fortunate scientists must adapt their research programs to suit the equipment on hand During the early years of his directorship at the Allegheny Observatory Schlesinger showed that he could do excellent work in the latter circumstance. The new telescope was put into operation seven years after he became director. During these seven years he used the Keeler Memorial telescope for spectrographic work. The emphasis was upon orbits of spectroscopic binary systems, and the results constitute a most impressive contribution to this branch of astronomy. In the course of this work Schlesinger discovered the rotation effect in the spectra of eclipsing binaries.

Many scientific men who concentrate upon a smaller or larger field of research specialize to such an extent that they have few interests in common with fellow workers in even closely related subjects This was certainly not the case with Schlesinger All of astronomy had his interest and his love As a young man, when he was observer in charge of the International Latitude Station at Ukiah, California, 1899–1903, he formed the habit of faithfully reading all the current astronomical literature, and he enjoyed doing this throughout his career This gave him an unusually wide knowledge that enabled him to give sound advice to many of his colleagues, here and abroad On this account, he was also one of the most sought men at the many scientific meetings that he attended.

He was a member of the American Astronomical Society since 1905, and was one of its leaders At the early age of forty-eight he was elected president, succeeding Newcomb and Pickering. His role in the International Astronomical Union was equally conspicuous and distinguished. He was vice-president for seven years (1925–1932) and president for the three-year term, 1932–1935.

High distinctions of various kinds, in recognition of his eminence as a scientist, came to him in abundance Among these were his election to membership in the American Philosophical Society (1912), the National Academy of Sciences (1916), and the American Academy of Arts and Sciences (1921) He was a foreign associate in the (British) Royal Astronomical Society (1914), corresponding member of the French Academy of Sciences (1932), correspondent of the Bureau des Longitudes (1938), and associate of the Royal Academy of Sciences at Upsala (1938) He received honorary degrees from the University of Pittsburgh (1920), and from Cambridge University, England (1925) In 1935 he was appointed officer of the (French) Légion d'Honneur The French Acad-

emy of Sciences awarded him the Valz Medal (1926); he was Gold Medallist of the Royal Astronomical Society (1927) and first George Darwin lecturer of that society; from the Astronomical Society of the Pacific he received the Bruce Medal (1929).

There is no doubt that he was an appreciative recipient of these distinctions, but it is equally true that they did not affect his humble attitude. Always a sincere scientist, scientific interests had the first place, and his personal ambitions were relegated to the background

One of his significant contributions to astronomy was the institution of the Neighbors' Meetings, unofficial gatherings of astronomers of the eastern part of the United States that usually occurred three times a year Most of these meetings were held at the Yale Observatory, with Schlesinger as the gracious host The good cheer that his presence brought to these gatherings will long be remembered by all those who had the good fortune of attending many or few of them

In 1900 he married Eva Hirsch of Ukiah, California, who died in 1928 The following year he married the former Mrs Philip Wakeman Wilcox, of Atlanta, Georgia, and New York City No account of his life would be complete without grateful acknowledgment of the devoted care that he received from his wife during this second marriage, and more especially during the last five years of his life when his health was failing He is survived by his widow and a son by his first marriage, Frank Wagner Schlesinger, now of the Franklin Institute.

DIRK BROUWER

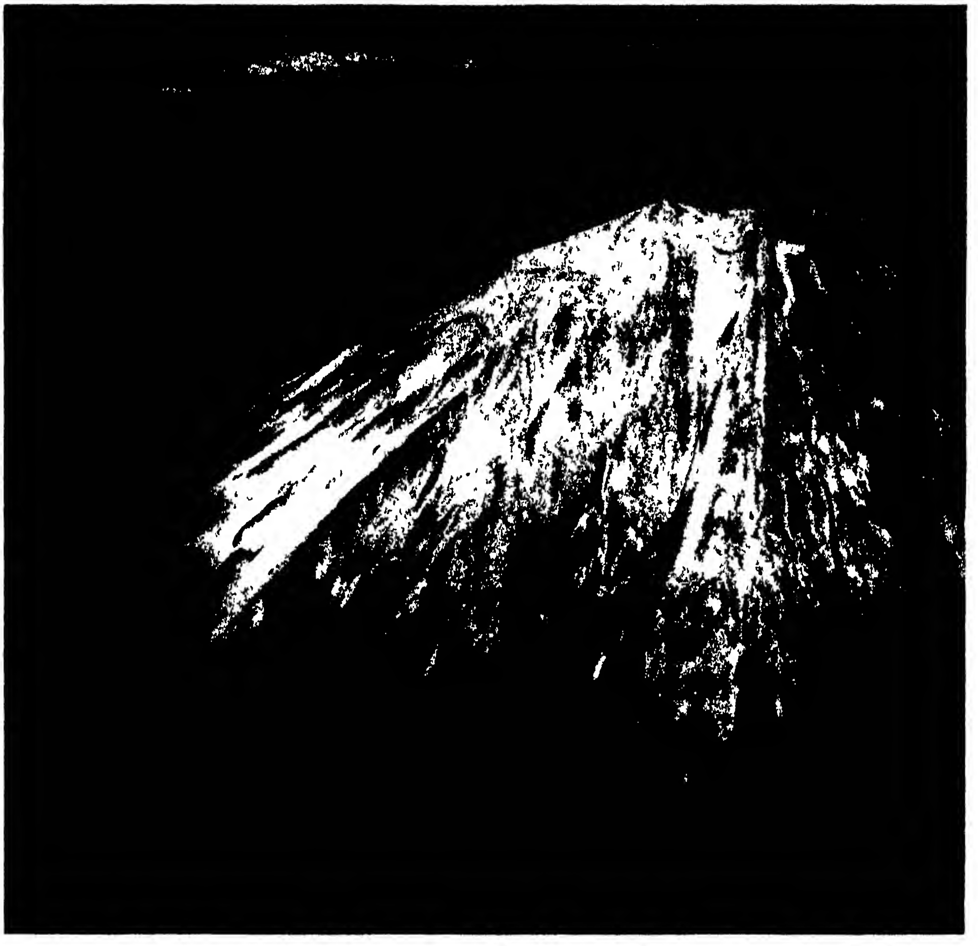
PHOTOGRAMMETRY AND AERIAL RECONNAISSANCE

PHOTOGRAMMETRY is the recently developed science and art of obtaining reliable surface measurements by means of aerial photography. Its beginning dates to 1851 when the photographic camera was first used for surveying purposes, but during the early years its application was rather limited because the surveyor was unable to find suitable heights from which to photograph the land to be surveyed This limiting factor was entirely overcome with the advent of the aeroplane which provided means for carrying the camera aloft to record rapidly and accurately the physical and cultural features of any area on the earth's surface Ordinary aerial photographs possess a wealth of pictorial detail, of inestimable value in many branches of science and engineering, but do not possess the accuracy of form necessary for mapping To overcome this defect has been the task of the photogrammetrist.

The rapidly expanding activities of the Army Air Forces on a world-wide basis created an urgent need for some quick method of charting large areas of the earth's surface which were either inadequately mapped or not mapped at all To meet this need a photogrammetric system was developed in 1941 and is being used today for the production of aeronautical charts

One plane, flying down planned courses spaced twenty-five miles apart, can photograph an area the size of the United States in 500 hours of actual flying time, and the photographs can be converted into small-scale maps in fifteen months by a force of 200 people The approximate labor cost of compiling the reconnaissance maps from the aerial photographs would be about one-half million dollars

These amazing figures are based on actual production by the Geological Survey during the past two years in making aeronautical charts for the Army Air Forces by a new system of aerial photographic mapping utilizing oblique photographs The method, developed by the Geological Survey and Army Air Forces, is commonly called the trimetrogon system because three cameras containing



AN "OBLIQUE" FROM TRIMETROGON PHOTOGRAPHY BY ARMY AIR FORCES

wide angle metrogon lenses of six-inch focal length are used for taking the aerial photographs.

An area of over 3,000,000 square miles of the earth's surface has been mapped to date in the Geological Survey by this system. To illustrate the speed attainable with this method, a map covering 89,000 square miles of Africa (approximately the size of Great Britain) was made ready for use within one week after the films were received in the United States

The Army uses various types of aircraft for photographic work Three cameras are mounted in each aircraft; the central camera points vertically downward and takes a photograph, commonly called a vertical, of the area directly beneath the plane; the two other cameras point obliquely downward to the right and left of the aircraft and take photographs, called obliques, covering the remaining area from horizon to horizon. In flight the operation of the three cameras is controlled by an intervalometer which regulates the simultaneous exposure of all three

The basic principles of surveying used in this type of mapping from aerial photographs are similar to those used in plane-table triangulation, in which horizontal or ground directions to common images from several stations serve to

locate their positions which then are used as a guide in the sketching of detail features The application of these principles of surveying to vertical photography became known as the radial line method, which has been used extensively in the past. The subsequent application of this radial line method of compilation to the trimetrogon system of photography led to the present reconnaissance system.

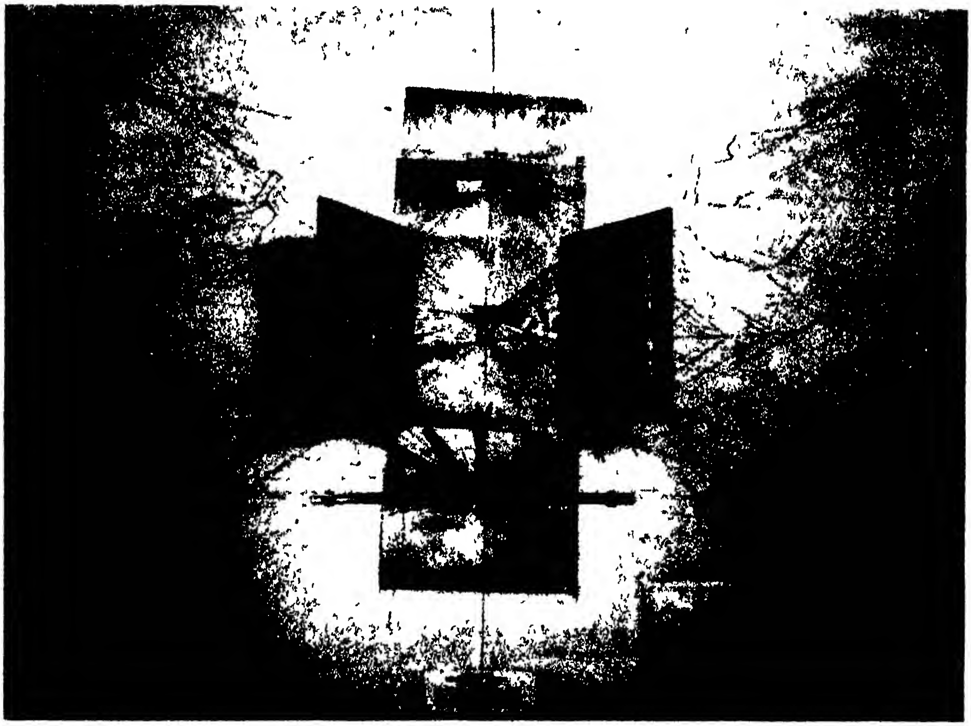
Each exposure of the three cameras yields three photographs covering a usable area of approximately 250 square miles The successive photographs overlap in the line of flight, giving at least two views of all points in the entire area to be mapped. This overlap is necessary in order to obtain directions to image points from several stations, thereby establishing their horizontal positions as in the plane-table survey

Since direction lines are necessary to establish the true positions of points on the map it is essential that these be horizontal directions, the same as those obtained with ground surveying methods. It naturally follows that, when some point on each aerial photograph is found from which all directions to points in the surrounding area are the same on the photograph as on the ground, this point can be used to obtain the necessary horizontal direction lines. There is a point on each vertical photograph which, for all practical purposes, satisfies this condition The vertical photograph, covering an area directly beneath the plane, contains the image of the ground point which would be at the foot of an imaginary plumb-line dropped from the plane at the time of the camera exposure. This ground point is called in photogrammetry the *ground nadir point* and its corresponding image on the photograph is called the *photograph nadir point.* There is a ground nadir point for each exposure of the three cameras throughout the flight of the aircraft and these points can be used as the origin of all direction lines for the photographic survey To obtain these ground direction lines from the photographs, both vertical and obliques, is a fundamental operation in this type of mapping.

The first step in the mapping procedure is the selection and marking of images on the photographs to serve as control points for the map compilation Included among these will be points of

METAL TEMPLATES ASSEMBLED OVER THE MAP MANUSCRIPT

known geographic positions. Before the photograph can be used further in the mapping operation the photograph nadir point must be located on the vertical photograph To do this requires analyses of the pictures to determine the amount and direction of the cameras' tilt at the instant of each exposure After this operation is completed, the first direction lines to be used are drawn on the vertical photographs so as to join directions as represented in the plane of an oblique photograph onto a horizontal or ground plane The Rectoblique Plotter, an instrument with a mechanical linkage which accomplishes this projection, was developed by the Geological Survey to be used for this operation The ground directions to points on the left and right oblique are drawn on sheets of transparent tracing paper by means of this plotter.



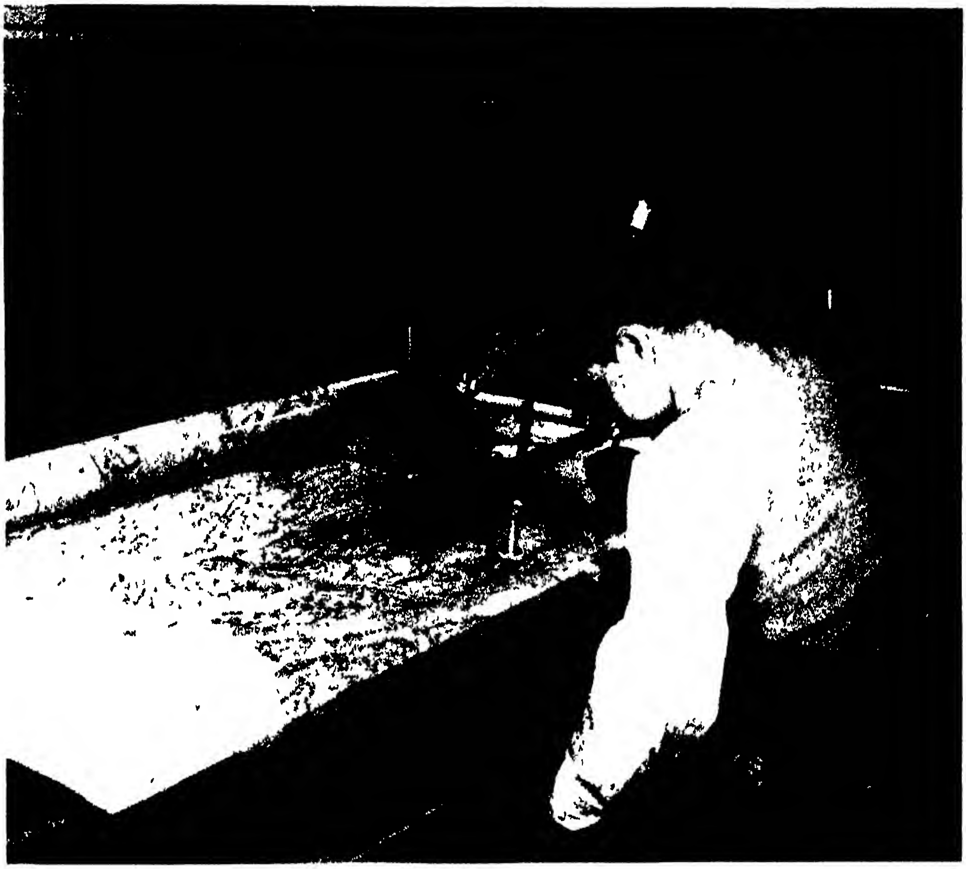
MODEL ILLUSTRATING TRIMETROGON COMPILATION

successive photograph nadir points, and are called *azimuth lines* These lines serve as base lines for the photographic survey since, on the ground, they would join successive ground nadir points and thus represent the course of the photographic flight

The next operation involves the determination of the ground directions to the points previously selected on the oblique photographs Since all direction lines used in the photographic survey must be horizontal, it is necessary to project the

These sheets, showing the direction lines from the ground nadir point to each selected image on the left and right oblique photograph, are called *paper templates*, one of which is made for each exposure of the cameras during the flight. The direction or azimuth lines previously established on the vertical photographs are then transferred to the paper templates, which now record all the direction lines to be used in the photographic survey.

The direction lines to images on the



THE VERTICAL SKETCHMASTER
IS USED TO TRANSFER FEATURES FROM THE VERTICAL PHOTOGRAPHS TO THE MAP MANUSCRIPT

photographs as recorded on the paper templates can now be used to locate these particular points in their true map positions Any particular area to be mapped is usually covered by numerous parallel flight strips spaced approximately twenty-five miles apart, and to make a map of the entire area requires the establishment of direction lines on paper templates for each flight Metal templates are then built from the paper templates and are assembled on a sheet of cellulose acetate on which the ground control points have been plotted. The intersecting metal arms establish on this sheet the positions of the main photographic control points

The features to be shown on the map are first outlined directly on the aerial photographs using stereoscopes, instruments which make possible the perception of differences in elevation

After completing the stereoscopic examination and delineation of details, the original map can be made The outline of the features as shown on the photographs is transferred to the map manuscript by the use of a vertical and an oblique Sketchmaster Utilizing the Camera Lucida principle, the Geological Survey developed these instruments to view the image of the photograph superimposed over the map manuscript, to match the image points marked on the photograph over their correct map position as shown on the acetate sheet, and to sketch the physical and cultural features thereon

JAMES LEWIS

PENICILLIN, THE NEW GERM FIGHTER*

BLOOD is of the animal kingdom. Bacteria, which poison blood and destroy cells and tissues, are of the vegetable kingdom. And sulfanilamide is a coal-tar derivative of the mineral kingdom. Until very recently man's most powerful known ally against the virulent little parasitic plants was this mineral compound of sulfur. It has been made into tablets for dosing by the mouth, into a solution for injection into the circulation, into a powder for dusting on wounds, and more recently various sprays containing sulfanilamide, and ointments, films, and other plastic membranes compounded of sulfanilamide mixed with soothing oils and analgesics have been fabricated as a dressing for wounds and burns Reports of the value of these treatments have come from many battlefronts, base hospitals, and casualty stations, as they have been coming too from civilian hospitals. Destructive infections have been cleared up; periods of illness and wound healing have been mercifully reduced; lives have been saved. Undoubtedly the discovery of the bacteriastatic properties of this synthetic chemical is one of the great achievements of modern medicine.

And yet, sulfanilamide is not an infallible remedy. There have been tragic disappointments. There are some serious germ infestations against which it seems to be powerless, or nearly so.

For example, a massive invasion of the blood stream by staphylococci, called staphylococcal septicemia, suffers only a moderate setback from even the most massive dosing with sulfonamide drugs Before sulfanilamide came into use the death rate from this blood poisoning was eighty-five to ninety per cent; under sulfonamide treatment it has been reduced to an average of sixty-five to seventy per cent, but that is still cruelly high. There is also a rare type of pneumonia caused by staphylococcal infection of the lungs against which the sulfa drugs are only feeble protection, though they are usually victorious in combatting the pneumococci and streptococci of ordinary pneumonia.

Gas gangrene bacilli yield grudgingly to sulfanilamide and only in a limited degree; a severe infection, even though heavily treated, is often fatal. Staphylococcal infection of burns is also a stubborn problem, for the microbes multiply with overwhelming rapidity among the dead and dying cells of the seared flesh, and they seem to be able to develop a tolerance for the drug. After the first day or two sulfanilamide does not seem to have much effect The British have produced a new drug, proflavin, for which many special advantages are reported. It is said to be more potent than the sulfonamides against the staphylococci. But since proflavin is toxic in the blood stream, and therefore can be used only on the outside of wounds, some surgeons will not risk it. A more recent British introduction is propamidine, another synthetic compound which also is applied only externally.

If that were all that could be said of the present medical front against sulfonamide-resistant bacteria, there would not be much point to bringing up the subject. But there are exciting new developments, powerful reinforcements already on the scene, and this time the defense comes, not from the mineral kingdom, but from the vegetable.

There is a tiny fungus, a greenish-blue scum similar in appearance to common bread mold. This fungus produces a substance, a fragile, unknown chemical compound, which is by far the most potent known agent against bacteria. Tests show that a dilution of one part in one hundred million is sufficient to prevent the growth of the highly infectious blood-destroying *Staphylococcus aureus*. The mould is known botanically as *Penicillium notatum*, and its mysterious

* Chapter from the author's forthcoming book, *Science at War.*

germ-fighting extract has accordingly been named penicillin

A recent case in a New England hospital will illustrate its power. The wife of a university official lay at the point of death, her blood the prey of a spreading infection of *Staphylococcus aureus*. Sulfonamide compounds had been used from the first appearance of symptoms, but with little effect; the invasion was racing through her system and would be fatal when the multiplication of bacteria reached the critical stage. The attending physician had heard of penicillin. Though not yet on the market it has been produced in a few laboratories for experimental and clinical testing, and as a last resort the doctor appealed for a dose for his dying patient The penicillin was rushed to him by airplane, injected into the poisoned bloodstream, and thereafter the golden germs simply fell away as though mowed down by an invisible reaper It seemed miraculous, but there are scores of equally moving rescues in the case histories of penicillin.

The discovery of this remarkable weapon against disease dates back to 1929 It was purely accidental. Dr. Alexander Fleming, in St. Mary's Hospital, London, was growing colonies of bacteria on glass plates for certain bacteriological researches One morning he noticed that a spot of mold had germinated on one of the plates. Such contaminations are not unusual, but for some reason, instead of discarding the impurity and starting fresh, Dr. Fleming decided to allow it to remain He continued to culture the plate, and soon an interesting drama unfolded beneath his eyes. The area occupied by the bacteria was decreasing, that occupied by the mold was increasing, and presently the bacteria had vanished.

Dr. Fleming now took up this fungus for study on its own account. He recognized it as of the penicillium genus, and by deliberately introducing a particle into culture mediums where bacteria were growing, he found that quite a number of species would not grow in its presence There were other species which did not seem to be bothered As he pursued his experiments the scientist noticed that the bacteria which were able to live with the penicillium were of the group known as gram-negative, so called because they give a negative reaction to a certain staining test named the gram-test, after its inventor. Those which were unable to endure the mold and died in its presence were gram-positive bacteria In his laboratory, whenever he wanted to get rid of a growth of gram-positive bacteria, Fleming would implant a little penicillium, and after that the microbes disappeared.[1]

There are beneficial bacteria among the gram-positive group, but it also includes some of the most predatory microbes known to human pathology For example, the causative agents of such horrible afflictions as septicemia, osteomyelitis, gas gangrene, tetanus, anthrax, and plague are gram-positive. The streptococci, staphylococci, and pneumococci are all of this grouping So the medical scientists began to speculate. Since the mold destroyed gram-positive organisms on a culture plate, could it be used to destroy gram-positive disease germs in the living body?

This question was the starting point of a medical research which has multiplied into many studies both in Great Britain and the United States. Fundamental to the whole program was the separation and concentration of the active substance, an achievement which was first accomplished by British investigators. The British also were first to report the treatment of human disease with penicillin. A team of biochemists and bacteriologists at Oxford has been especially active, and has reported many cures In the United States, studies have been made at the College of Physicians and Surgeons in New York, the Mayo Clinic,

[1] Fleming later discovered that there are a few gram-negative bacteria which are vulnerable to the mold.

the National Institute of Health, the Evans Memorial Hospital of Boston, and practically all the large pharmaceutical houses Since 1941 the development of penicillin in quantities sufficient for clinical use has been a major interest of the Committee on Medical Research, and its support of the work in several centers has undoubtedly had much to do with the progress recently made At the same time, independent groups have contributed important findings which are part of our advance

Recent clinical tests leave no doubt of the medical and surgical value of penicillin It has cured acute cases of blood infection, bone infection, eye infection, has conquered severe infestations of gonorrhea, has cleared bacteria from massive burns and other wounds—and has done these jobs often after the sulfonamides had failed, and with no adverse reactions in the patient A surgeon has reported, for example, that whereas the death rate of staphylococcal blood poisoning before sulfanilamide was eighty-five to ninety per cent, and after the introduction of sulfanilamide was reduced to sixty-five to seventy per cent, "even our limited use of penicillin has brought it down to 36 per cent " And, he added, "with further knowledge of this new material, we think it can be reduced to 20 per cent." Practically every complication of staphylococcal infection except one seems to yield Endocarditis, a bacterial infestation of the delicate lining of the heart, is resistant even to penicillin

The principal factor limiting the use of the new germ-fighter has been production. Enormous quantities of the mold have to be grown to obtain even meager supplies Also, the product is somewhat unstable, sensitive to changes in temperature, and therefore has to be kept under refrigeration. Until we know its chemical formula and are able to synthesize it, we are wholly dependent on the fungus to produce penicillin by natural vegetative processes.

Penicillium notatum is cultivated in bottles or vats, and grows on the surface of a liquid from which it draws nutriment. As the velvety mat spreads and thickens, it releases by-products which descend and dissolve in the medium, and by processing this liquid the substance is extracted. On evaporation the residue appears as a reddish brown powder, and this is penicillin as the doctor gets it The powder dissolves readily in water, and is administered by injection into the blood stream, though it may also be laid on a wound by spray or other means Penicillin has been used to treat wounded soldiers and sailors hospitalized home from the battle fronts, and practically all of the present production is going into military and naval use

In the summer of 1943 production operations were still in the pilot plant stage, although considerable progress has been made toward increasing the yield Back in 1941 it was necessary to process one hundred litres (about 26½ gallons) of the liquid to get one gram (the 30th of an ounce) of the extract, and this extract was only about twenty-five per cent "pure" penicillin By 1943 the strains of fungi had been so selected and cultivated for high yield, and the methods of processing so improved that one hundred litres were producing ten grams having eighty-eight per cent penicillin The processers are confident that in time they will be able to concentrate their extract to a purity close to one hundred per cent

Meanwhile, the number of concerns engaged in production has been increased Even with no gain in percentage of yield, substantial increases in output may be expected from the multiplication of producing units An interesting development is the turning of a group of Pennsylvania mushroom growers to the new industry. They are familiar with the ways of fungi and instead of mushrooms for the food market they now cultivate penicillium for the drug market.

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UNITED NATIONS' CONFERENCE ON FOOD AND AGRICULTURE

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THE Conference, classed under *Foreign Affairs*, was held at Hot Springs, Virginia, under the auspices of the State Department, between May 18 and June 3, 1943. It was presided over by an elder statesman in agriculture, The Hon Marvin Jones of Texas The first topics before the Conference were inquiries into natural science—productions and behaviors of agricultures (but not including fisheries), and physiological needs and psychological wants in the patterns of diets that vary from country to country. The technical field was not *terra incognita* to scientists. During the inter-war decades, researches in production, distribution and consumption of foodstuffs were active and widespread, and developed with superior experimental and statistical methods. Deep spadework was done during the depression of the thirties. The League of Nations and the International Labor Office; the International Institute of Agriculture; governmental Departments of Agriculture more or less over the whole white world, but especially in the United States where the yearbooks from 1936 to 1942 were veritable mines of information; the National Resources Board; independent research organizations of widely different kinds; these, with innumerable special researches by widely scattered scientists, had clarified many issues and notably extended the horizon of information. Even for such backward countries as China and India, elaborate studies had been issued by Buck, Mukerjee and Rao. It is fair to add that, since our first National Nutritional Conference was held as late as 1941, publications under the League of Nations during the thirties constituted the broad public introduction A rough forecast of the recent Conference was made in the January (1943) number of *The Annals* of the American Academy of Political and Social Science by F. L. McDougall of Australia, long an official in the League of Nations. The representatives of the different countries attending the Conference met more as scientific colleagues than as political delegates.

The less direct topics on the Agenda were sociological and economic. They were composed of questions less definite at the moment, perhaps even incidental, but later to be of major importance—problems of stocks and distribution, communications, transportation and refrigeration, exchanges of goods and services, equations of balances of trade.

Finally, not stressed on the Agenda—somewhat like uninvited guests casting shadows over restrained deliberations—were long-term, secondary problems of interrelations of nutritional reform to clothing, housing, sanitation, education, rates of birth and death, rates of growth

and changing densities of population, and eventual migration from higher to lower densities during coming generations. All in all, the subject matters on the Conference program represented inquiries primarily into natural science, and secondarily into social research.

The Conference met to consider post-war goals of world-wide and ultimate "freedom from want" in relation to food and agriculture. The word "want" was used more in the sense of material well-being, less in the sense of "want" used in economics. "Freedom from want" presupposed freedom from hunger; "freedom from fear" presupposed "freedom from want." Thereafter, freedom from want and fear presupposed balanced and world-wide expansion of economic activities, which to achieve would need *long-term post-war reforms*—collectivization of world agriculture and socialization of world trade in foodstuffs.

President Roosevelt several years ago broadcast the national reproach that a third of our population was under-fed, under-clothed, and under-housed. Then Henry A. Wallace revived the doctrine of the "Revolution of the Common Man." Anglo-American solidarity in August, 1941, created the Atlantic Charter. At the beginning of the European struggle arose the slogan (somewhat modified from the previous war): "Food will win the war and make the peace." Since the United States entered the war, Europeans (belligerent and neutrals) have taken this slogan literally; the United States has become the geographical name for "manna-from-heaven." Under these circumstances, it became apparent that, whether the war were to last three or five years after 1941, the United States needed vigorously to organize resources in agriculture and to plan the distribution of agricultural products at home and abroad. Under the emergency predicted by the slogan, these objectives were publicly focused in the United Nations' Conference on Food and Agriculture.

Scope of Agenda

The Conference derived directly in spirit, and indirectly in convocation, from the Atlantic Charter Point 5 in the Charter stated that the President of the United States and the Prime Minister, Mr. Churchill, representing His Majesty's Government in the United Kingdom, "desire to bring about the fullest collaboration between all nations in the economic field, with the object of securing for all improved labor standards, economic advancement and social security," with "access on equal terms" for all countries "to the trade and to the raw materials of the world which one needed for their economic prosperity," as set forth in Point 4 Early in the war the British Government erected an outpost; as early as August, 1940, Prime Minister Churchill had accepted for the victors the obligation to build up reserves over the world, so that all countries should recognize that victory of the Allied Nations would bring, for all, immediate food, freedom and peace. A conference was held in London in September, 1941, at which practical plans were started to provide liberated peoples "with articles of prime necessity" directly after the war, and a commission was set up under Sir Frederick Leith-Ross.

It is important to envisage the collateral economic implications In the convocation of the Conference, the State Department included within the intent of "improved labor standards, economic advancement and social security," with access to trade and raw materials, the special improvement of nutrition for man and of the agriculture necessary to maintain it. Under these circumstances, the inclusion of food and agriculture under Points 4 and 5 of the Charter represented an important, dynamic interpretation by the Department of State.

The countries represented at the Conference numbered forty-four, including several refugee governments (combined population 1.6 billion): *Europe*—United

Kingdom, Norway, Netherlands, Belgium, Greece, Iceland, Luxembourg, Free France, Czecho-Slovakia, Poland, Yugoslavia, Russia; *Africa*—Egypt, Liberia, Union of South Africa, Ethiopia; *Asia*—China, Iraq, Philippines, India, Iran; *Western Hemisphere*—Canada, United States, Mexico, Cuba, Dominican Republic, Haiti, Venezuela, Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, Colombia, Ecquador, Peru, Bolivia, Brazil, Paraguay, Uruguay, Chile; *Oceania*—Australia, New Zealand In the absent minority of the world were twenty enemy and neutral countries as follows (combined population 0.5 billion): *Europe*—Finland, Sweden, Denmark, Eire, German Reich, Switzerland, Portugal, Spain, Italy, Hungary, Roumania, Albania, Bulgaria; *Asia*—Turkey, Arabia, Afghanistan, Thailand, Tibet, Japan; *Western Hemisphere*—Argentina Since the Agenda of the Conference dealt with long-term post-war reforms, all countries of the world are eventually to be brought under the aegis of the reforms and innovations inaugurated by the United Nations

The topics on the Agenda covered the broad field of *long-term post-war reforms* in relation to national patterns of diet and to scope and efficiency of national agricultures. No discussion was proposed for the immediate factual role of food in winning the war or making the peace Throughout the transactions of the Conference there were comments on monetary stabilization, lower tariffs, elimination of arbitrary and unilateral obstacles to trade, freedom of the sea and air, stabilized foreign exchanges—in general, freedom of the flow of goods and services as broadly stated in the Atlantic Charter.

Between the termination of food relief and the reestablishment of peace economy, a period of transition will emerge which may occupy several years There must be two stages in the long-term post-war reform of agriculture. One is preliminary repair of devastation of war, which may be extreme after a country has been "scorched"; there will be much of such reconstruction in Poland and Greece, less in Holland and Norway. The second stage represents the planned shift from calories to protective food-stuffs, which will vary from country to country in accordance with the respective patterns of pre-war diet.

Demand and Supply, Surplus and Shortage

The deliberations of such a Conference rest finally on statistical data. Agricultural and commercial reports in 1938 were the best in history, representing a cumulation of improvements in methods and interpretation during the inter-war period The war has thrown statistical estimates into confusion, least for those pertaining to fruits, vegetables and grains and most for animal products. Rationing, somewhat paradoxically, has confused the situation, but in outside countries not under ration, disturbances in distribution provoke baffling uncertainties For many of the other forty-three members of the Conference, the League of Nations and the International Institute of Agriculture knew more about their food productions in 1938 than did their local officials

In order to enter upon reforms of diet and agriculture, each country will need to know what it obtains from harvest and import, from season to season; and what it ingests from season to season Production comes first: we follow crops into use; we do not, as a rule, trace use back to crops. When we study the protective foodstuffs we give special attention to consumption; but dealing with bulk and calories, we start with crops and animal husbandry. Our knowledge of protective foodstuffs grew partly out of the study of poverty-diets occurring during the depression of the thirties. Chemical research on vitamins and their syntheses,

biological experimentation on the effects of vitamin deficiencies and clinical observations on naturally-occuring deficiencies have proceeded hand in hand in some countries, especially in Britain and the United States. Unfortunately for the world-wide dissemination of data on standards of diets, few countries have Orrs, Wilders and Stiebelings.

Farmers in this country follow one or more of three supporting influences when "goals" of increased production are set up in order to create exportable surplus: (a) federal and state Departments of Agriculture, with Extension Service and County Agents, and supported by various loans and subsidies from the federal government; (b) institutional farm organizations, such as the National Grange, the Farmers' Union, and the Farm Bureau Federation, (c) cooperatives, which in some regions are very influential in directing farm practice. The difficulty in the past was that farmers were expected to "venture" into increased production, with consequent inflation but later risk of deflation. Indeed, many of the so-called "surplus problems"—national and international—in the disposition of farm products (called "commodities in chronic surplus" in the Agenda), had their origins in the stimulation of production for the purpose of export or self-sufficiency. In substituting a doctrine of plenty for that of restriction, reforms in foreign agricultures must not become the bases for autarchy.

Records of imports and exports are usually more accurate than those of crops; it is the flow that is difficult to follow. Each of the *forty-four* countries represented at the Conference (and later the absent enemy and neutral countries) will need to prepare post-war programs of agriculture and goals of production of foodstuffs, and to tabulate these on their widely different pre-war patterns of national diet. Thereafter each country will need to revise the traditional pattern of its diet—which in most countries had records only of protein, fat, carbohydrate and total calories—to include essential amino-acids and fatty acids, iron and calcium (perhaps other minerals), and thiamine, riboflavin, niacin, ascorbic acid, vitamins A and D, and perhaps others. Crop reports will need to be revised and reviewed to take account of protective foodstuffs as well as of traditional staples

These protective components will need to be scheduled in the various native products and in imports from usual sources Unfortunately, adequate analytical, experimental and clinical information will not be available to most of these countries; consequently farmers and households will be confused, and progress delayed Also, few countries will be politically in position to face the legislative question of subsidies to improve diet of low-income classes. Practical applications will take time and will undergo trial and error; old superstitions and taboos, even religious ceremonials, will need to be corrected The backward countries will offer deep-seated objections; but even among advanced peoples there will be resistance to the transformation of traditional patterns of diet into modern nutritional patterns. That the agricultural "goals" of 1943 need to be heavily revised and enlarged into "master plans" for 1944 illustrates trial and error procedures under even the most expert farm administrators How well the forty-two allied nations have learned from Great Britain and the United States during the present Conference will be revealed only in the decade after the resumption of peace, on paper at least.

We must separate occasional shortage from continuous scarcity, and crop failure from income failure. The famine of crop failure is usually one of scarcity of caloric foodstuffs; the hidden hunger is usually due to scarcity of protective foodstuffs. "Food-piles," "carry-overs," "buffer stocks," "ever-normal gran-

aries"—the variously-named warehouse-stocks for needs in occasional exigencies—do not cover the ultimate requirements of low-income classes. India has a bad monsoon failure once in ten years but has severe income failure every year. Since causes, locations and extents of different kinds of shortages are widely different, no single remedy is appropriate Long-term stocks are possible only for grains, sugar, coffee, lard and mess pork in cold storage, dehydrated vegetables properly packed, and possibly dried fruits and legumes The public finds it disconcerting to see, side by side, plans for "ever-normal granaries" and projects for control and allocation of "surpluses" in staples like coffee, wheat and sugar.

When, therefore, the Conference placed upon member-countries the injunction to prepare schedules of crops in the order of importance of nutritional components and schedules of diets by regions and income classes—all of which will be needed if the proposed reforms are to be seriously undertaken—the Conference exacted tasks of large and continuing difficulty. What is needed for guidance in each country is formulation of facts and projects in the national nutrition, such as has been prepared for this country under the editorship of John D. Black and published under the title "Nutrition and Food Supply" in *The Annals* of the American Academy of Political and Social Science for January, 1943, and supplemented by the various issues of the United States Department of Agriculture. It is to be hoped that Conference procedures will lead to statistical clarification of factual occurrence, extent and localization of surpluses and deficiencies in particular food supplies, in all significant countries. These are not to be adjudged by reports on crops, imports and exports; in some instances not even by data of total supply, disappearance and ingestion. A number of countries are net-exporters of caloric foodstuffs; there are few significant net-exporters of protective foodstuffs. In any year, the food supply of the world may be unknown to the extent of plus or minus five per cent, perhaps in some years ten per cent.

Qualitatively evaluated, we tend to exaggerate dietary deficiencies and underestimate dietary excesses It is accepted in this country—with the highest standard of living ever achieved by a population as large as ours—that before the war a third of the inhabitants were poorly nourished (in the mid-thirties) in respect to protective foodstuffs, to an extent permitting objective (if indirect) diagnosis of mild degrees of malnutrition If this held true in the United States, it must have been equally true in other surplus countries, such as Australia; and worse in Argentina, where field surveys of the pampas revealed surprising neglect in the use of protective foodstuffs. Certainly, applied to larger and older countries in the world, if Americans have (mild) malnutrition in a third of the population, this will be found to affect half of the population in many countries, and two-thirds or even three-fourths in certain large countries like China and Japan—as confirmed by surveys. In India, the usual deficit in food supply is ten per cent. into the "famine zone." Without question, a careful, dynamic study of the statistics of the pre-war food supplies of the world would indicate surprising extents of shortages in protective foodstuffs; often more than moderate, with here and there relative surplus of caloric foodstuffs. In our country possibly a third of the population over fifty years of age is over-nourished and over-weight due to excessive ingestion of calories (including alcohol) which leads to cardiovascular disease, long-recognized in life-insurance statistics.

In all countries, some neglect of protective foodstuffs was due to ignorance; in most countries it was due still more to lack of purchasing power in low-income

classes. Sometimes noted are extraordinary perversions in agriculture, most glaring in India; but it is possible that in many advanced countries, surveys of agriculture would suggest that the diet of domesticated animals has been superior to that of the human population—because animal husbandry was under the influence of scientific doctrine while the pattern of the human diet was surprisingly under the influence of superstition, prejudice, and ignorance

With due regard for occasional or even conspicuous instances of excessive ingestion of foodstuffs in advanced countries—as revealed in overweight, obesity, cardiac disease, and diabetes—these may safely be left to the medical profession. But deficiency diseases due to shortage of protective components of the diet cannot be left to the medical profession, since prevention is not to be secured except through education on scientific nutrition brought to the public schools, to parent-teacher associations, households and public eating places. Presumably, the urgency of war will give to post-war reform in dietary patterns the high rank in public health needed to assure well-being in all income groups

Implications

Directly explicit and indirectly implicit in proposed global planning are the following factors:

(1) The contrast of the low level of gross national production in the depth of the present depression with the present higher level provokes the social reflection that it ought to be a first-order function of a state to maintain in peacetime the high gross production attained in wartime. Surely it is to be regarded as a reflection on society that it can rise to high production for purpose of slaughter but cannot continue high production for purpose of conservation—that it perfects the standard and plane of killing but is unable to perfect the standard and plane of living.

(2) In the platform of adequate nutrition for all countries, it seems to be accepted that accustomed patterns of different diets can be so modified as to enable all peoples to be fed adequately on the gross supply of foodstuffs, as this may be modified and expanded by plant agriculture, animal husbandry, forestry and fishing. But when it is realized that two-thirds of the inhabitants of the world live in areas where population presses hard on food supply, it becomes obvious that more or less coercion (of an educational nature) may need to be applied regionally to rejection of dietary dicta of religions, superstitions and taboos When we deal with national patterns of diets, we come to appreciate distinctions between bodily needs for nutrients and consumers' desires for foodstuffs The backward peoples must be taught to be fed scientifically, just as domesticated animals are handled by farm management

(3) It is assumed that the science and art of agriculture have been so developed as to be applicable horizontally and vertically, acceptable to all regions, latitudes and longitudes, in all soils and climates, and to all peoples—highly advanced, less advanced, decadent, backward or primitive. We lay out "goals" and "master plans" for agriculture which, in the absence of any climatic calamities in peacetime, might be expected (costs aside) to double gross production of feedstuffs, caloric foodstuffs, protective foodstuffs and domesticated animals on per capita bases within ten years. Such rural objectives ought to be relatively feasible in advanced countries with low densities of populations, but they become more and more difficult in regions with high densities of populations.

(4) More widely and insistently, it is being urged that advanced races ought to accept migration of other races from

areas of high to areas of low density of population, particularly when unutilized agricultural resources are readily available in countries of low density of population. Perhaps not the "open door" of migration, but at least notably liberalized quotas of immigration are being advocated. In part, the problem is one of divergencies in industrialization and in definition of living standards; but if these could be resolved on the basis of accepted per capita requirements, the racial problems of interbreeding would still remain.

(5) Like reservations apply to clothing and housing. These are closely related to sanitation and to nutrition, with many points of contact; difficulties lie in religions, superstitions and taboos, which radiate through the living of two-thirds of the inhabitants of the world. And reform can not associate with illiteracy

(6) It is assumed that "free trade" will replace "restriction"; this is better stated by saying that freer trade is to replace less-free trade. It is expected that each country will attempt first to elevate its attained standard of living.

(7) It seems to be assumed that technical reforms in agriculture, freer trade and efficient distribution of foodstuffs from country to country can be accomplished within the present scope and application of scientific sanitation. Unfortunately, such assumption is not well-founded. Religion, superstition, taboo and ignorance directly and indirectly influence practices of agriculture and distribution and uses of foodstuffs in Africa and Asia (disregarding small *foci* elsewhere), representing nearly two-thirds of the entire world population. A study of the problems of communicable diseases of animals in Asia and Africa indicates the enormity of the task of protecting the Western Hemisphere and Europe from the insanitation of Asia and Africa. Involved also are large questions of sanitation in relation to the distribution of communicable diseases of human beings—the control of typhus, yellow fever, malaria and bubonic plague, to mention the most prominent infections. Lesser questions concern the supply of pure water, sewage disposal, reduced mortality of infants, and elimination of intestinal parasites, in all of which Europe and the Western Hemisphere are far ahead of Africa and Asia, both in theory and practice

(8) Planned economy, including important social relations outside of commercial enterprises, might lead to a three to four billion increase in the population of the world in the course of one or two generations. The rapidity of such increase of population would depend upon the success of the sum total of efforts to make life "secure," to raise the statistical standard and plane of living, to lower the proportion of the population submerged in destitution, and to achieve the so-called "freedom from want" and "freedom from fear." Let it be emphasized that in such eventual increase of world population the rate of growth would be expected to rise most in Asia and Africa, possibly in Russia and Brazil, but not notably in western Europe, in the Western Hemisphere or in Australasia. The net result would be a declining proportion of Europeans and their descendants and an increasing proportion of African and Asiatic races in the world, as indirect but inevitable result of what has been called the "Revolution of the Common Man." Thus we revert to Malthus: pressure of the population on food supply, instead of pressure of food supply on the population as proposed by the projected reforms.

Prospect

Each of these reforms may seem *qualitatively* sound on technical and statistical grounds. But on making *quantitative* appraisal of methods to be used, and of the *time element*, it is difficult to avoid the realistic conclusion that any moderate

attainment expected within a few years may require a decade or more; that the larger realization expected in a decade may require a generation or two. The progress will be one of slow evolution rather than rapid revolution. If we measure in this country the ignorance prevalent in young, as well as old, on matters of food supply, nutrition, disease and sanitation; if we recognize how slow public progress here has been since the close of the first World War, and then multiply this reservation by from two to twenty in estimating the prospects of reform in various foreign countries, we obtain a more realistic forecast of the future than is found in political programs.

Two broad proposals were adopted at the Conference: that each participating country first make a national survey of food supply, nutrition, and agriculture, and then decide to what extent deficiencies in national nutrition are due to inadequacies of agriculture or to low national income and inequality in distribution. Here science will run counter to tradition and custom in most countries.

From this point on, in each country farm activities and non-farm activities are to be reformed. (a) Farm activity is to be reformed intensively and extensively by local advances in the uses of the art and science of modern agriculture. In some countries, it may be felt proper to propose parcellation of land; a changed system of taxation of land; loans to agriculturists; public assumption of stocks, carry-overs and marketing; and various enactments or subsidies to assure the desired proportion of caloric and protective foodstuffs in the national diet. Some countries will require allocation of open sea fishing; this will be defined as related to the internal food supply and will rest objectively on international adjustments. Some of these steps have been tried only in several advanced countries. One special point in the reform is technological, perhaps financial, aid of backward countries by advanced countries.

(b) In each of the countries included in the projected reform will be non-farm reform as well as farm reform. Extension of refrigeration is a much-needed improvement in transportation. Transportation and communications will need to be adapted to projected closer international relations; indeed, it is suggested that appropriate control of transportation and communication by the state for internal purposes may be found necessary to effectuate international control of transportation and communication for global purposes. In general, it becomes clear that an outstanding feature sought in the proposed reform is extension of public enterprise, partly in substitution of private enterprise but also as an extension into fields not yet developed. But farm relief means commercial profit, since farming is to remain private enterprise.

(c) Included for each country, for both the rural and urban population, are the aims of high production, full employment, large national income with equitable distribution for consumption, and savings by regions and classes. For many countries, this will involve internal monetary reform. That such monetary reforms within states may involve revaluation of money, allocation of bank credit, and redistribution of wealth, even at the risk of expropriation of capital, is accepted by reformers as possibly inevitable, following the history of monetary aberrations during the past thirty years.

(d) For each country is implied a planned economy between farm and non-farm, also within farms and, of course, within industries. The extreme proponents of this reform do not shirk from vertical and horizontal projections, because reform is designed within countries to bring about the end of traditional laissez faire; thus the best prospect of success in such reform is held to be clear realization and full enunciation of the direct applications and the indirect implications for private enterprise.

Within the participating countries, the initial reforms obviously go far beyond food supply and agriculture, as fully recognized in the transactions of the Conference. Orders of precedence, methods of application, volume and velocity of planned changes are, of course, all subject to variations from country to country, depending upon material circumstances and psychological characteristics. Certainly reform in China would be different from reform in India; reform in Asia and Africa would be different from reform in Europe; and reform in Europe would be different from reform in the Western Hemisphere. What is sought by proponents is clarity of objectives (ends), and continuous pressure (means) toward practical beginnings in all countries Each participating country will need to define food production, commercial surplus or deficit, demonstrable dietary deficiencies and the supplementations needed to make local patterns of diet adequate. So much, briefly, for the internal national projects, the speed of which will tend to be incautiously precipitated by sentiment in some countries and retarded by fear in others.

Once these forty-four countries have prepared their surveys of diet patterns and nutritional deficiencies, and their agricultural potentialities and deficiencies, these separate national internal reforms will be sought to be welded into an international body of reform. Here enter many difficulties, fully recognized by the proponents of the movement. These difficulties lie largely in international relationships.

(1) With respect to the exchange of goods and services as such, it is assumed that each country will seek high production, full employment, large national income with savings offset by capital investment adapted to the country's policy. This will ensure enlargement in absolute volume and possibly also in the relative proportion of foreign goods and services—expansion in foreign trade, in short. Such interchange is, indeed, stipulated as necessary to the predicated high production, full employment and large national income within countries. Both positive and negative influences will need to be invoked. The negative corrections imply reduction in impediments to the flow of goods in foreign commerce, of which both the difficulty and the desirability are fully recognized in the diplomatic circles of all liberal countries. The positive method of encouragement of the flow of goods and services in foreign trade lies partly in internal adaptations and in high production, but mostly in adjustments to be sought under the captions which follow.

(2) With respect to the facilitation of the media of exchange, it is accepted in theory and practice that expanded foreign commerce is not to be sought on the basis of bilateral trade or unilateral valuation of money or barter, but instead on the basis of multilateral commerce, as illustrated recently in a book, *The Network of World Trade,* issued by the League of Nations. The proponents of reform are conspicuously united in advocacy of the expansion of foreign commerce on the multilateral pattern, with every possible removal of impediments to foreign trade. Before the United Nations at present are two proposals—one drafted by Lord Keynes for the British Exchequer, the other by Harry D White for the United States Treasury—looking toward the restoration of order and computability in the field of foreign exchanges, the elaboration and stablilization of the media for payment of goods and services in multilateral trade, and for seasonal equation of trade balances between countries.

(3) With respect to foreign investments, two things seem to be anticipated. With due recognition of the valuable services of foreign investment in the development of the world since the begin-

ning of the industrial revolution, such foreign investment can not be expected to be revived after the next peace in the form that was acceptable and effective prior to 1914. The material interests of the borrowing countries must be projected and conserved to an extent not invoked prior to 1914; both lenders and borrowers need to envisage an improved type of foreign investment. The subject of foreign investment is, of course, connected with developments in transportation and communication, freedom of restraint in the flow of goods in multilateral trade, and especially with the determination of a world-wide and effective stabilization of currencies and exchanges. When we consider together the difficulties and dimensions related to the free movement of goods in international commerce and to the freedom of communications and efficiency in the operations of the media of exchange, and contrast these with the reform in food and agriculture as envisaged in the transactions and resolutions of the recent Conference, we come to foresee what the word "global" means; and come also to appreciate—fully envisaged by the supporters of the projected reform—the extent to which advances in the several interrelated fields must be encouraged and elaborated if the horizontal extent and the vertical depth of the global reform in food and agriculture are to be secured in anything like the time expected by the recipients of improvements in the less advanced and backward countries of the world.

(4) The tremendous sinkings in ocean tonnage, the geographically irregular restoration by new construction and consequent deterioration of transportation by canal and rail, the veritable revolution in transportation by air, together with possible expansion of transportation by highway more or less over the world—these together create problems both large and urgent, on which directly rest the success of reform in food supply and agriculture. What is sought in general terms is freedom—freedom of the seas, of the air, of ports and communications —all these in the international sense, with appropriate reflections of freedoms within countries. In view of the planned increase in global production and the related expansion in international commerce, the equitable and efficient correlation of newer and older modes of transit will be one of the outstanding problems in the transition to peacetime economy in many countries

In order to forecast volumetrically, so to speak, the dimensions involved in these problems, we need merely to point out that food and drink use one-fourth to one-third of the national income in the most advanced countries, three-fourths of the national income in the most backward countries having high concentrations of population, with other countries occupying stations all the way between. Highly important for the success of the reform in food supply and agriculture are coincidal reforms in clothing, shelter, sanitation services, and education; indeed, it is not to be expected that satisfactory reforms in food and agriculture can be attained without such simultaneous intensive and extensive reforms. But in the early stages of correlated reforms, the large proportion of global income devoted to nutrition is such as to give food supply priority in global reform

(5) Finally, we arrive at what later will become the most difficult phase of the projected reform—namely, the relations between populations in different continents Reactions will soon become vividly manifest. When the tabulated reports on diets and agricultures of the forty-four countries are contrasted from standpoints of actual nutritional patterns, relations of population to area of cultivatable land (dynamic density of population), birth rates, death rates and expectations of life, and prospective rate of growth or decline of national popula-

tions, it will then become apparent that reform will be relatively easy and quick in a country in which high efficiency of agriculture tends to produce a pressure of food supply on population which will make feasible the attainment of optimal diet. But the reform will be extremely difficult and deferred in a country in which demonstrable efficiency in agriculture still fails to produce such a food supply for the population involved as will prove nutritionally adequate, unless supplemented heavily by imports One has only to compare India and the United States The total area of India is less than that of the farms in this country; since the population of India is now estimated at four hundred million and that of the United States at one hundred and thirty-five million, it becomes arithmetically obvious that each inhabitant in the United States possesses, so to speak, in land within farms, three times as much area as is possessed by each inhabitant in India in all the land of that country If we were to draw the contrast between land in farms in this country and land under agricultural operation in India, the per capita divergence would become still more glaring We have in this country no such major division within the population as is to be seen in India between Hindu and Moslem; no "untouchable caste" and "sacred cow" of which Americans have not even a hypothetical picture. The agriculture of this country is scientific; that of India is chained with superstition and taboo, shackled with ignorance and disease. Our country potentially requires no imports to supply adequate diet; adequate diet in India could only be secured through colossal imports, for decades at least. Adequate diet in India would be accompanied by an increase in the rate of population growth, which no one expects in the United States.

From this contrast emerges total difference in prospect for the projected reform in the United States and in India. With these as extreme illustrations, all of the other countries would occupy intermediary positions, more or less difficult according to their differences in population, areas and resources

The summary of views and recommendations of the Conference, issued before adjournment, apply to the countries which have accepted, perhaps with misgiving but with more or less enthusiasm and emotion, the projected reform in food and agriculture. In the expectation of Allied victory, however, this leaves out of consideration twenty countries, depending upon the outcome of the treaty of peace Also, it leaves unclear the future status of colonies and dependencies, in the broad sense. Included thereunder are: (a) all of Africa lying between the Union of South Africa and the countries from the Levant to the Atlantic that border on the Mediterranean Sea; (b) also all of Asia outside of Japan, China and Asiatic Russia; (c) all of the islands south and east of Asia and north of Australia If the status *quo ante bellum* of colonies and dependencies remains, one type of difficult problem will result; if all colonies and dependencies are to be freed, another type of intricate problem will emerge It is a principle of the proponents that their reform is to apply to all regions and countries—advanced, less advanced and backward, all must be brought in. This not only involves extraordinarily complex and unsuitable patterns, both of diet and agriculture, in the regions to be retained or freed, but also the solution with respect to the future status of these large areas will complicate greatly the reforms in transportation and communications, currency and exchange and foreign investment. If these areas are to retain status *quo ante bellum,* reform of agriculture and of pattern of diet in their retained areas remains the responsibility of the

countries controlling them. But if these colonies and dependencies are to be freed and established as autonomous units, is their participation in this reform to rest upon their inexperience in government, or are they to become for a generation the charity charges of the world?

The British Commonwealth of Nations and the United States combine ideology and driving force in this projected reform; we are to be the major donors, the others are to be mostly recipients. If colonies and dependencies are to be reformed, in patterns of diet and agriculture, outside the frameworks of the British Commonwealth of Nations, Holland, Belgium and France, such enforced emancipation of large areas would be more violent than the separation of the Western Hemisphere from Europe in recent centuries

It can not be suggested that these questions are far-fetched These questions will arise just as soon as the Interim Commission spreads out the reports from the forty-four countries on national pattern of diet and national status of agriculture; they will become even more obvious when the unrepresented neutral and ex-enemy countries are eventually included in the subsequent survey. The peoples of Asia and Africa—of their own volition but aided by encouragement of Anglo-American ideologists—expect, ask for, and will later demand that the promises held out in the Anglo-American recognition of the "Revolution of the Common Man" shall be incorporated into their standard of living, and with energetic foreign assistance. The entire tone of the Conference seemed favorable to collective planning, for occupations and for regions. The type and extent of the reconstruction of agriculture in the first decade of peace will reveal whether the oldest and most individualistic of occupations has become amenable to planned economy.

In seeking post-war reform in the world, we need to recognize that the evils it seeks to eradicate were not the product of this war or of the last war; nor were they the causes of this war or the last war. However, it is hoped that within the forty-four countries we may find that solidarity for reform which they did not possess during the inter-war period or prior to the first World War. And it is hoped, in some almost magical way, to induce the defeated peoples, under-privileged neutral countries and backward countries all over the world, to join us in a reform for which they do not have the preparation we possess. But should such outside countries perversely decline to go with us, are we prepared—having proclaimed that "the world can not live half slave and half free," that "peace is indivisible," that success in reform for the whole world may be nullified by refusal of significant countries to participate—to impose reform by force? Finally, what is to be the policy of the United Nations if less advanced countries backslide on their agreements to cooperate in reforms being carried out for them as well as for the leading countries?

Proposals accepted by the Conference, in principle and theory, do not bind the members and do not become accepted projects, but pass as recommendations first to the Interim Commission, and then—through them (perhaps directly)—to the participating countries, later to emerge in some form of legislative enactment or executive directive in each of the countries concerned It is presumed that such enactments and directives will enable a central commission on operation and management to coordinate legislation in participating countries for the purpose of setting up accepted policies of storage, commercial allocation, price acceptance and donation It is obvious that if such concurrent legislation is made elaborate, it will include elements of cooperative marketing, consumers' cooperations, stockpiles, transportation control, and facilitation of foreign exchange. Experi-

ence suggests that tactics of follow-up will require more attention than original enactment and compliance.

Acceptance by countries participating in the Conference is expected to be followed promptly by legislative enactments and executive directives appropriate in each country Illustrations of such reforms of the diet are. enrichment of flour and bread; minimal standards for vitamins in processed vegetables, fruits and dairy products, prescription or proscription in processing; and standardization in the preparations of vitamins. Indeed, such regimentation may go as far as to prescribe feeding of dairy animals for purpose of natural enrichment of milk and butter Stress is to be laid on the coordination of production (plus imports) with consumption, using the yardstick of optimal nutrition. Some of these provisions will sound as distant to many of the countries as the proposals of the National Resources Planning Board now sound to most Americans

The Conference took action, on appointment of an interim commission, to draw up plans for permanent organization from which could follow a second international conference, with a more specific agenda, after a suitable lapse of time following the reestablishment of peace. Whether ex-enemy and neutral countries will then join with the United Nations, and accept their leadership in reform of food and agriculture, can not now be predicted.

A week after the adjournment of the United Nations' Conference on Food and Agriculture, it was unofficially disclosed that a United Nations Conference on Relief and Rehabilitation is in the course of preparation The questions of responsibilities for losses, costs and outlays will loom larger in discussions of relief and rehabilitation than in the program for the reform of food and agriculture. Neither this reform nor relief and rehabilitation can be settled until political peace and geographical adjustments are attained

Subsequent to the adjournment of the Conference, the State Department issued formal "*Recommendations*" of Sections and a "*Final Act.*" These contained declarations of principles and policies with detailed submissions of projects and proposed obligations When these documents shall have been delivered to the home governments of forty-three countries and shall have been translated into forty-two foreign languages, the most extensive international collaboration in the history of the world will have been verbally launched.

SOME QUAINT CONCEPTIONS OF NORTH AFRICAN NATURAL HISTORY

By ARTHUR LOVERIDGE
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SOME time ago my attention was called to an Algerian dispatch regarding a lizard. Apart from minor exaggerations, such as increasing the creature's length by fifty per cent., the reporter described an African chameleon with sufficient accuracy as to leave no doubt regarding its identification His comments called to mind the surprisingly good descriptions of this creature contained in an old book whose bicentenary passed unnoticed last year.

This book, *An Essay towards a Natural History of Serpents*, was printed in the year 1742 for the author, the Reverend Charles Owen of Warrington, Lancashire, by John Gray, at the Cross-Keys in the Poultry, near Cheapside With commendable industry the erudite Owen has brought together everything he could find regarding serpents and, in addition, a surprising amount of matter that has nothing whatsoever to do with them I have nothing but admiration for Mr Owen, who has so carefully documented each statement and whose proof reading is almost beyond reproach In the course of a search for his remarks upon chameleons, however, I came upon so many quaint references to fighting in Libya in bygone times that a few quotations might be entertaining. In such quotations, except for the old fashioned double *s*, the original spelling is preserved.

The introductory remarks suggest at least one use for a snake's tail which has escaped the perspicacity of our modern herpetologists. Owen writes:

Serpents are provided with Tails of different Length and Size; these also are necessary to adjust their Motion, and guard them against Stimulation of Flies. In winged Serpents, the Tail serves as a Rudder to govern them in flying through the Air, and in the marine Serpents, they serve as Oars.

With the last remark no fault can be found, but the affectionate intentions attributed to a snake's flickering tongue appears to be decidedly imaginative:

Mention is made by Historians of harmless Serpents, and of Persons who have tamed Serpents, and whose Hair has been kissed by a tame Dragon, and which, with its Tongue, gently lick'd its Master's Face.

We read of other green Serpents in the Indies, that are indulged with little Cottages made of Straw, where they spend their solitary Hours, till the time of eating invites them out, then they repair to the House, where they fawn upon their Masters, and eat what is set before them, and then retire to the Huts of Indulgence.

We have often been told that the present is a "total war," and yet our Government appears to be taking no steps to mobilize our snakes. What a surprise a few thousand rattlesnakes would cause in enemy trenches if dropped there at night by parachute! For, formerly:

In Times of War, Serpents have been prest into the Service. Thus Heliogabalus (Emperor of Rome, . . .) gathered together several Serpents, contrived a Method to turn them loose, before day, among his Enemies, which soon put them into a terrible Hurry, and a Motion, that was a Trial for their Lives; the Sight of the crooked Serpents being far more dreadful, than the Whizzing of a straight Arrow.

Hannibal having procured a great Number of Serpents, put them into earthen Vessels; and by another Device, and in midst of the Engagement, convey'd them into Antiochus's Fleet, which proved more dreadful than Fire-balls, and feather'd Weapons, that flew amongst them. At first it seemed ridiculous to the Romans, that they should arm themselves, and fight with earthen Pots; but when they were broken, an Army of Snakes rush'd out, which so terrified the Marines, that they immediately yielded the Victory to Prusias, the Carthaginian Hero's Friend.

But, coming to Libya, it is reassuring to learn that:

The Water which amphibious Serpents frequent, receives no venemous Tincture from them. When Marcus Cato commanded in Africa (the Element of poisonous Animals) . . . marching the Remains of Pompey's Army through the Lybian Deserts, observes, how the Army being almost choak'd with Thirst, and coming to a Brook full of Serpents, durst not drink for fear of being poisoned, till convinced by their Superiors, that their being in the Water, did by no means infect it: Upon which they refreshed themselves with Water from the Serpentine River.

Further troubles beset the Roman Army in Libya, however, for we read that:

The Dipsas or Dipsacus is a little venemous Reptile of the Aspick-kind, less than a Viper, but kills sooner; and is most remarkable in this, that when it bites, the Poison brings an unquenchable Thirst on the Person affected, who finding no Relief, runs to the Water, and drinks till he burst asunder The Poetick Historian observes how Aulus, an Ensign-bearer in the Roman Army in Africa, was slain by this Serpent; at first he felt little or no Pain from the Bite, but as soon as it began to operate, he was immediately scorch'd to death. . . . The more hot the Climate, the more terrible the Wound, as it is in that hot Country, where they have no Springs, but a few salt Wells, which increase the animal Appetite of Thirst.

Now comes a description of the blunt-nosed viper (*Vipera ammodytes latastei*) which Owen confuses with the smaller horned sand viper (*Cerastes cerastes*) of the same region:

The Ammodytes is a Serpent very venemous and fierce, of a sandy colour, black Spots, and of about a Cubit long. The Wound given by the Female, the weaker Vessel, is said to be most dangerous: Its jaws are larger than the common Vipers, and from some Eminencies upon the Head, like a Tuft of Flesh, is called Cornutus. Its Wounds prove fatal without a speedy Cure. It is found in Lybia, a Limb of Africa.

The *Cerastes* is a Serpent of the viperine Kind; its Head resembles the Cornigerous; it belongs to the Lybian and Nubian Family: Its Teeth are like those of the Viper, and it brings its Successors into the World after the same manner. Its Constitution is very dry, which refines and exalts its Poison, and makes it more dangerous; the Wound is generally attended with Distraction, and continual pricking as with Needles. Some say, 'tis of a whitish Colour, others arenaceous; it loves sandy Habitations, where it often surprises the unwary Traveller: And all agree 'tis of a most cruel Nature; and therefore in some Places 'twas made the Executioner of Malefactors.

Its Wounds soon kill, if one of the Psyllian People be not immediately called in. N.B. These Psylli are a noted people of Syrenaica in Africa, endued with a natural Faculty of destroying Serpents upon sight, and curing their Wounds by a Touch of the Hand. . . .

And we learn that Cato:

. . . had in his Army a Number of those Natives called Psylli and Marsi, the supposed Aversion of Serpents, . . . It is said, these Psyllians inchanted Serpents, who fled at the sight of them, as if their Bodies exhaled some corpuscular Effluviums that were most offensive to Serpents, and put them into such pain that made them run To these, the General added another Set of Persons, famous for curing the wounded by other Methods, and all little enough, Serpents being the Lords of the Country through which they were to pass.

Where the River Bagrada is I can not say, it is possibly in the country of the Bagara tribe, Sudan, where elephants and pythons occur; but even the most indulgent reader would have difficulty in swallowing the following Owen, referring to the strength of snakes, writes:

A certain Number is sent out with little Bodies; others are of monstrous Bulk, and capable of making the strongest Efforts against all the Attempts made to destroy them, yea, are strong enough to contend with Elephants, the greatest of Animals and conquer them. *e. gr.* Attilius Regulus, the Roman General in Africa, is said to encounter a Serpent in that Country, of vast Strength and Stature, near the River Bagrada, 120 Feet long, which he and his Army could not subdue, without discharging all their Engines of War against it; and, when conquered and flea'd, its Skin was conveyed to Rome in Triumph. . . .

The Ethiopian Dragons just mentioned, have no proper Name, and are only known by a Periphrasis, *viz.* Killers of Elephants. The Method is, by winding themselves about the Elephants Legs, and then thrusting their Heads up their Nostrils, sting them, and suck their Blood till they are dead.

Presently we find Owen relating how various tribes resort to eating even poisonous species with impunity:

In the Kingdom of Congo in Africa, the Negroes roast the Adders, and not only greedily feed upon them, but esteem them as a most delicious Food.

The Circulatores, or Dealers in Serpents, devour'd at their Tables even their Heads, and pour'd the Gall into their Cups when they drank, laughing at their Neighbours Timidity, who transform their Imaginations into Bug-bears.

and rightly concludes:

That Poison is not so dangerous, if it does not mix with the Blood. Even that venemous Liquid may be tasted, yea, and swallow'd without mortal Effects, say some of the Learned. Hence it is, wounded Persons have been directed to get the Venom immediately suck'd out, which has been practis'd without ill Consequences to the Sucker. For this Method of curing venemous Wounds by Suction, Avicenna, an old Arabian Philosopher and Physician, is quoted; who says, that those who suck the Poison are in no danger, so their Teeth be sound and perfect, and their Mouths be free from all Ulcers. At Rome was an Order of Servants, whose Office was to suck venemous Wounds, which they did with Safety and Applause.

As we read the account of the King of the Serpents one is apt to conclude that Owen is confusing cobra and basilisk until we see his enchanting illustration, for, apart from its eight legs, the figure is evidently intended to represent a chameleon, whose casque or helmet has been interpreted as a crown.

But 'tis most probable, that the royal Stile is given to this Serpent, because of its majestic Pace, which seems to be attended with an Air of Grandeur and Authority. It does not, like other Serpents, creep on the Earth; which if it did, the sight of it would not be frightful, but moving about, in a sort of an erect Posture, it looks like a Creature of another Species, therefore they conclude 'tis an Enemy. Serpents are for Uniformity, therefore can't endure those that differ from them in the Mode of Motion. 'Tis said of this Creature, that its Poison infects the Air to that Degree, that no other Animal can live near it, according to the Tradition of the Elders famous for magnificent Tales. These little Furioso's are bred in the Solitudes of Africa, and are also found in some other Places, and every where are terrible Neighbours.

Following some substantially accurate descriptions of a chameleon's tongue, we come to an engaging account in which the biting possibilities of its blunt little teeth are extolled in a way to shame even the most flamboyant reporter of today:

. . . 'tis about a Foot long and spotted, has large Eyes starting out, the Tail has several white Rings round it, and its Teeth sharp, and strong enough to penetrate an Armour of Steel: it has a slow Motion, but where it fastens, 'tis not easily disengaged. . . . It frequents Cairo, and other Places, is found among Hedges and Bushes; mutes like a Hawk; swallows everything whole. It moves the Feet of each side alternately, but runs up Trees very fast, and lays hold on the Boughs with its Tail. Leo and Sandys say, the Neck is inflexible, and it can't turn without moving its whole Body: the Back is crooked, the Skin is spotted with little Tumours: the Tail long and slender, like that of a Rat; when it sucks in the Air, its Belly swells, whence some think that the Air is part of its Food. One Author says, it subsists only upon Air; another says, 'tis a vulgar Error.

With the object of settling this point:

A Certain curious Gentleman made the following Experiment, when he lived at Smyrna, in Asia-minor: He bought some Cameleons, to try how long they could be preserved alive under Confinement; he kept them in a large Cage, and allowed them the Liberty to take the fresh Air, which they suck'd in with pleasure, and made them brisker than ordinary. He never saw them either eat or drink, but seem'd to live on the Fluid in which we breathe.

After all the Gentleman's Care about 'em at Smyrna, all of them died within five Months; and having opened the Female, found thirty Eggs in her, fasten'd one to another in the form of a Chain. . . . The Cameleon is an oviparous Animal. J. Jonstonus says, it has above a hundred Eggs, from Piereskius, who nursed a Female on purpose to make Observations upon the Subject.

And finally, while on the subject of eggs the following interesting description of incubators is included:

In some Parts of Asia, and at Grand Cairo in Egypt, they hatch their Chickens in Ovens; each Oven contains several thousand Eggs which the Country brings in, and have their Eggs returned in Chickens. By this Method, they generally want some integral Part, as an Eye, a Claw, etc., which may be owing to a Want of equal Impression of Heat, tho' the artificial Warmth be continued. There are Thousands, yea Millions at a Batch, thus produced in Egyptian Ovens;—and may as well be in Europe, if our Bakers had the knack on't.

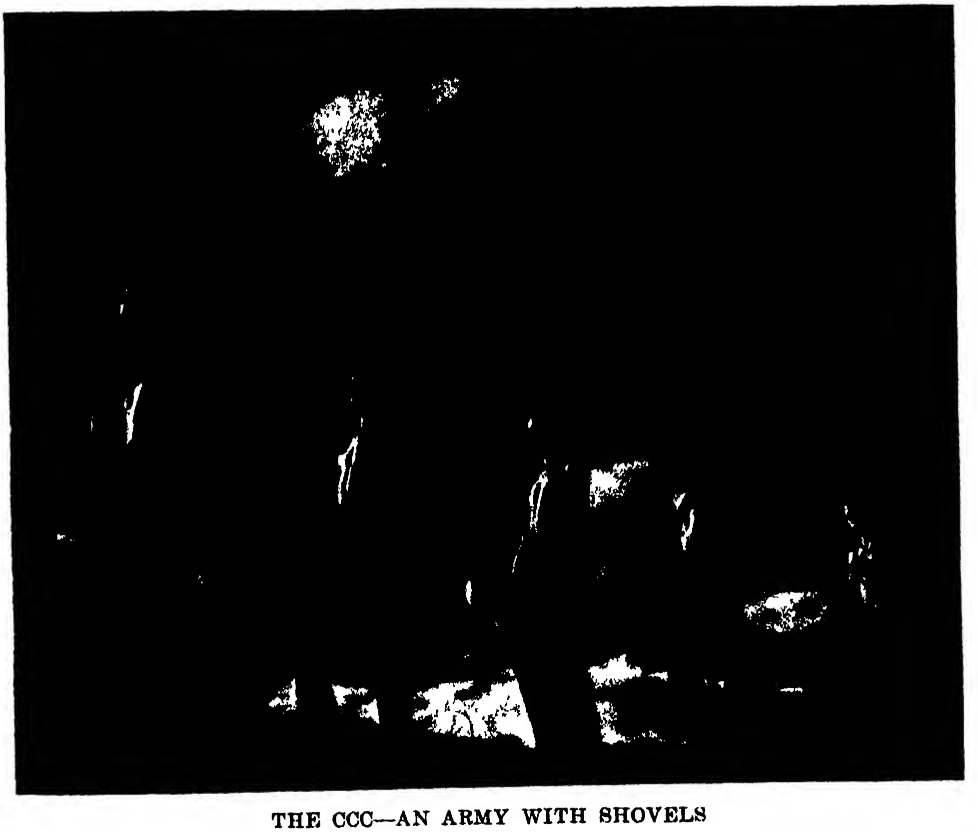
THE CCC AND AMERICAN CONSERVATION

By Major JOHN D. GUTHRIE

FORMERLY GENERAL INSPECTOR, CIVILIAN CONSERVATION CORPS

THE great adventure of American youth in the conservation of this country's resources ended on June 30, 1942. It lasted for nine and one-third years—less than a decade. Obviously, the neglect, waste and destruction of many generations could not be repaired or restored in a decade, but a heartening start has been made by the CCC. In that short time the Civilian Conservation Corps wrote its name into the economic, social and educational history of this country; it did even more than that—it started a change in the landscape of a nation. Maybe the CCC has taught America a lesson in real national thrift, which is another name for conservation of natural resources.

Although a global war was not in the national picture when the CCC was started, by 1939 National Defense had come in, and by 1941 War had entered. Conservation of natural resources is important to a nation at all times, but in days of war it is vital. The CCC did not come any too soon. It shoved forward the conservation of our natural resources by many years; many felt there was still



THE CCC—AN ARMY WITH SHOVELS

THEY WERE TAUGHT RESPECT FOR THE FLAG AND GOOD CITIZENSHIP

need for such an agency, to serve as practical work and health training centers for youth under draft age. When war ceases, the need will be increased tenfold.

The conservation picture of this country has too long been a dark one. That picture was strikingly painted in 1940 by Henry A Wallace, now Vice-President, then Secretary of Agriculture, in these words:

> Thoughtlessly we have destroyed or wounded a considerable part of our common wealth in this country. We have ripped open and to some extent devitalized more than half of all the land in the United States We have slashed down forests and loosed floods upon ourselves. We have torn up grassland and left the earth to blow away. We have shallowed and befouled our creeks, rivers, and other living waters. We have built great reservoirs and power plants and let them be crippled with silt and debris, long before they have even been paid for.

Out of a realization of the waste of natural resources and of the waste of idle youth, President Franklin D. Roosevelt, in 1933, combined the two into one of the most constructive programs this country has ever adopted. He had long been convinced of the urgent need to check the heedless waste of our natural resources, and when the depression furnished idle manpower, he seized the opportunity to remedy both. It was a bold stroke of conservation statesmanship However, it was obvious that President Roosevelt had given much thought to this use of idle labor in the cause of the country's natural resources. It was no overnight idea, for even in March, 1933, less than a month in the White House, he surprised a group of less imaginative foresters, park executives, naturalists and conservationists with details of what kinds

of forest, soils, park and stream improvement work should be done and how it could be done, and he drew for them a specific organization chart. After the announcement of these advance plans, he wanted action—immediate action—and he got it. In less than three weeks after Congress passed the Emergency Conservation Work Act of March 31, 1933, he had the first CCC camp set up and working in the George Washington National Forest in Virginia. By July 1, 1933, there were 232,000 youths and veterans at work for natural resources, and by September, 1935, there were over 500,000 CCC boys in over 2600 camps distributed throughout every state, and in Alaska, Hawaii, Puerto Rico and the Virgin Islands. In 1942 the President recommended the continuation of a reduced Corps to be used as a nucleus for a post-war youth labor organization, but Congress abolished the CCC on June 30, 1942, setting June 30, 1943, as the final liquidation date. The last camp, at work on an Army airbase, was closed on August 12, 1942. During the life of the agency, a total of 2,965,959 juniors (ages seventeen to twenty-three) and 189,165 war veterans were enrolled in the Corps.

The Civilian Conservation Corps charted more than a gigantic program of conservation of the natural or renewable resources of this country. It charted effective cooperation between four executive departments, it charted a plan to help youth by the most effective and practical method—to give it worthwhile outdoor work to do, to require an honest day's work of each youth, with no semblance of the dole or "made work." And it should be emphasized that the CCC returned to the American people fair value for what it paid these youths and veterans. It was healthful work in the outdoors, out in the forests and parks and on the soils of this country.

The CCC set a new pattern for the most practical kind of education for

A CCC CAMP STREET IN THE APPALACHIANS

CCC YOUTH PLANTS A YOUNG PINE TREE

youth yet found in this country; it gave youth serious, worthwhile outdoor jobs to do—real work day by day—jobs which had to follow blueprints and specifications, jobs which when done were inspected and had to stand up. Here was no make-believe, no playtime work. Youth responded. They could see the sense of what they were doing, they could see progress day by day, and soon there came a pride in worthwhile work well done. They were doing a man's work. They were learning the *how* and *why* of work for conservation; they learned proper work habits and proper work attitudes. It was not office nor "white collar" work, it was work on the land. As Dr. Paul T. David says in *Youth and the Future* (American Youth Commission), "The physical organization and character of the CCC has been determined from the first by the nature of the work to be done. Conservation work cannot be done in a workshop, it has to be carried on at the points where the natural resources in need of conservation are located."

These boys came to realize that it was for *their* country, for the good of the whole people, it was not only the finest kind of education for any and every American youth, but it was also the finest kind of training in citizenship. It was essentially public service work. The Corps set a pattern in the practical teaching of youth which it is believed is going to have far-reaching effects on the American system of education; it was education through daily conservation work; it was learning-by-doing. The CCC between 1933 and 1942 proved this pattern was workable.

The average American was a strong supporter of the CCC, but he had little

conception of what the CCC actually did for the conservation of his country's natural resources, or how much the Corps did for youth itself The variety of work was great and total accomplishments were stupendous The job lists and the statistics were staggering but without interpretation they meant little to the average citizen

The CCC left the nation a vastly improved natural resources balance sheet This record carries such items on the asset side as hundreds of millions of young trees planted, over 100,000 miles of truck trails built, many thousands of miles of telephone lines laid, hundreds of new state parks developed, millions of acres of farm lands benefitted through erosion control and the rehabilitation of drainage ditches, better grazing conditions on the public domain, and an increasing wildlife population The present and future value of the work completed was estimated as having a present and future value of $2,000,000,000

LEARNED THE DIGNITY OF LABOR

Now that the CCC has been finally liquidated, what do the figures on conservation accomplishments mean in terms of national security, national welfare and the future? The truck trails built, the fire towers erected, the telephone lines laid and the fire prevention

GATHERING TREE SEED IN SOUTHWEST VIRGINIA

and fire hazard removal work completed meant that on June 30, 1942, the United States had a far stronger forest fire prevention and suppression system than this country had ever had before It meant that at a time when the Nation faced possible incendiary bombing attacks on its vital forest and other natural resources, the country had the truck trails, the fire towers and the communication systems necessary to combat them The erosion control work done in the dust bowl and on southern, middle western and western

WHAT THE CCC FOUND ON THE TVA

lands means that at a time when the Nation's food production machinery may be taxed to capacity, it has 40,000,000 acres capable of producing much more food than would have been possible had the Corps not been organized. It means that the West, which produces the bulk of the beef, wool and hides needed for victory, has more water and more grass because of CCC grazing control and range water conservation work.

The trees planted by the Corps meant that over two and two-thirds million acres of lands which were bare and unproductive ten years ago are now green with growing trees planted by the youngsters of the Corps The millions of man-days spent by CCC enrollees on the forest fire front lines since 1933 mean that today this country has millions of acres of growing and mature timber which otherwise would have been destroyed The work done on park lands means that the capacity of our recreational areas to accommodate visitors has been increased by millions

Some Conservation Details

Let us look in some detail at a few of these conservation results from the CCC. The CCC put in 6,459,403 man-days on fighting forest fires. What does this huge total of man-days of work mean? It means, among other things, the hardest kind of work; it means danger from falling limbs and burning snags, or being surrounded by fire—and perhaps burned to death—as forty-two CCC enrollees and five foreman were in the past nine years It means fighting forest fires

hour in and hour out, day and night It means that the mere boys of the CCC fought fire on a thousand fronts, to save vital American resources badly needed right now in the World War Two CCC enrollees and three foremen were awarded the American Forest Fire Medal for heroism in fire fighting, four given posthumously. The annual average acreage burned over dropped by 27 per cent when the CCC got out on the forest fire line They saved forests for human needs by preventing their going away, or to shelter and protect wildlife. Many of these young trees will be ready to harvest by the sons and grandsons of these CCC boys. Trees grow slowly; the CCC was planting for the future It also means that the seed from which these young trees sprang had to be collected, and sown in forest nurseries. And the CCC spent 6,111,258 man-days in preparing land, sowing seed, weeding, transplanting, watering, and tending these two billion young trees before they were ready to be set out on the two mil-

WHAT THE CCC LEFT ON THE TVA

up in smoke and flame; the records of both the U. S Forest Service, the State forest services and the National Park Service show this

The CCC boys set out some two and two-thirds billion tree seedlings. What does the planting out of 2,688,527,000 young trees mean? It means that nearly three million acres of otherwise barren, denuded or unproductive land now have a chance to grow timber for human needs, or for human enjoyment, or to help stop valuable soil from washing

lion acres Many millions of America's denuded acres yet remain to be planted, to make them productive And back of all this, the CCC had to collect 875,970 bushels of conifer seed and 13,634,415 pounds of hardwood and other seed to plant in the nurseries to grow the seedlings to plant on the barren soils.

Also the forests on some four million acres have been improved and bettered by having the poorer, crooked, diseased trees cut and taken out, thus giving more light and moisture to the trees remain-

MILLIONS OF ACRES ARE NOW GREEN BECAUSE OF THE CCC

ing This is a permanent improvement, a real forestry investment, foresters call it "timber stand improvement" The material removed went into fuel wood, poles, fence posts, guard posts and charcoal Forestry foremen supervised this stand improvement At least four million acres of American forests are in better condition because of the CCC boys

The boys built 126,230 miles of truck trails and minor or forest roads, and in addition, they maintained 580,995 miles Of what benefit are all these miles of road? It is helping fire crews to get to forest fires while they are still small and while there is a chance to stop them, or put them out This road mileage opened up new forest and park areas for use of the timber and other resources, or for public recreation and enjoyment The 88,883 miles of telephone lines they built also give quicker action on fires and help in better administration of forest and park lands—federal and state Many a mile of these CCC roads is now helping in better protection of the country

Forests are also killed by enemies other than fire The annual toll by fungous diseases and forest insects is silent, steady and enormous The insect and fungous attacks on the forests go on, through peacetime and wartime Blister rust kills the white pines in the Northeast and in the Northwest To check or control tree and plant diseases, the CCC worked on 7,955,707 acres Besides, forest and other insect pests—like pine and bark beetles, spruce sawfly—Mormon crickets and grasshoppers were checked or controlled on 6,161,742 acres

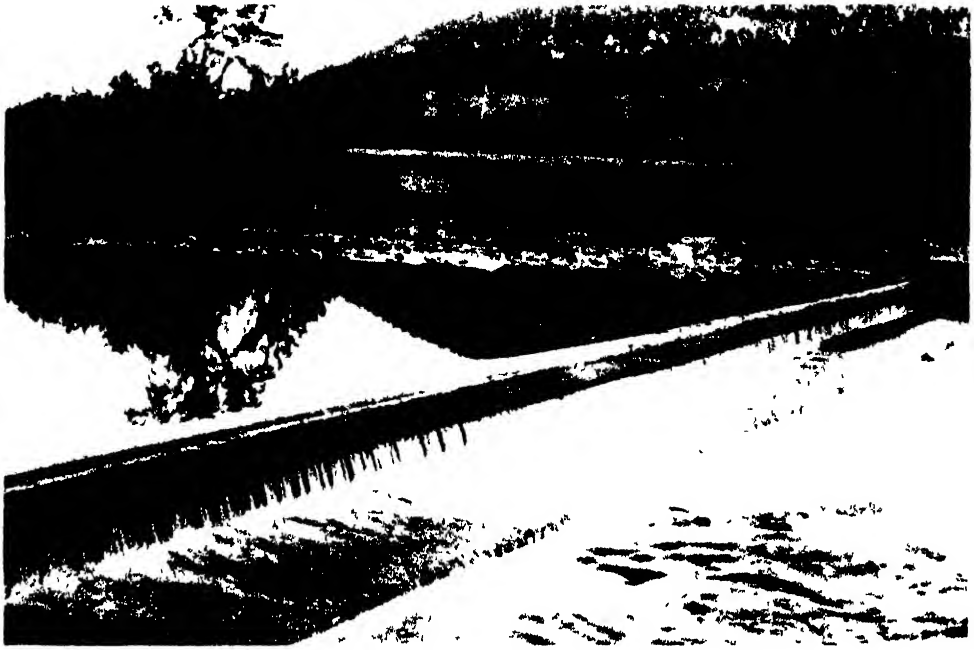
For many years before the CCC came, the soils of this country had been washed, and were still being washed away, going down millions of gullies, clogging small streams, creeks, rivers and harbors with silt, mud and debris The invaluable topsoil of the nation was being lost forever Not only topsoil fertility, but also the soil itself was being lost And the tragedy of it was that it could have been prevented Millions of acres had been abandoned as farm land We talked of marginal and submarginal

farm lands, rural slums, share-croppers, farm migrants, "the ill-fed, the ill-housed and the ill-clothed" The CCC came, and provided manpower to do something practical about this vital soil problem

Soil salvage work was done in forty-five states, stretching from coast to coast Soil erosion control meant doing many different jobs Some of the more important were: check dams, seeding and sodding, tree planting, diversion ditches, terracing, channel outlets, water spreaders, quarrying, contour furrows and ridges, road and wind erosion treatment Accomplishments on these run to large figures, but pretty small in the picture of what was needed to be done, and what remains to be done For example 318,076 permanent and 6,341,147 temporary check dams were built, 33,087 miles of terraces were put in; 431,321 outlet structures were built; 638,473 acres were planted to stop sheet erosion During its nine years of existence CCC accomplished erosion control on more than twenty-five million acres, but this is only a start on the millions of acres needing attention This is essentially farm land, though much erosion was controlled on Western grazing lands Today in these war times this improved land is better able to do its share in the farm battle to out-produce the Axis, this fact is due in no small part to the CCC in starting the protection of our most precious natural resource—the soil

Grass or forage is an important natural resource throughout the West, the Middle West and the South Sheep and cattle must have forage and water, especially on the semi-arid ranges of the West Often grass, weeds and other herbage are unusable because there is no, or not enough, water, or the water is too far from the forage This means poor distribution of stock, unused range or overgrazed range To help this situation on national forest, public domain and Indian reservation range, the CCC improved 12,346 springs by damming or otherwise piping water, 3,311 waterholes, and built 9,805 small reservoirs or what the Western stockmen called "tanks"

THE BOYS CLEANED UP AFTER THE NEW ENGLAND HURRICANE



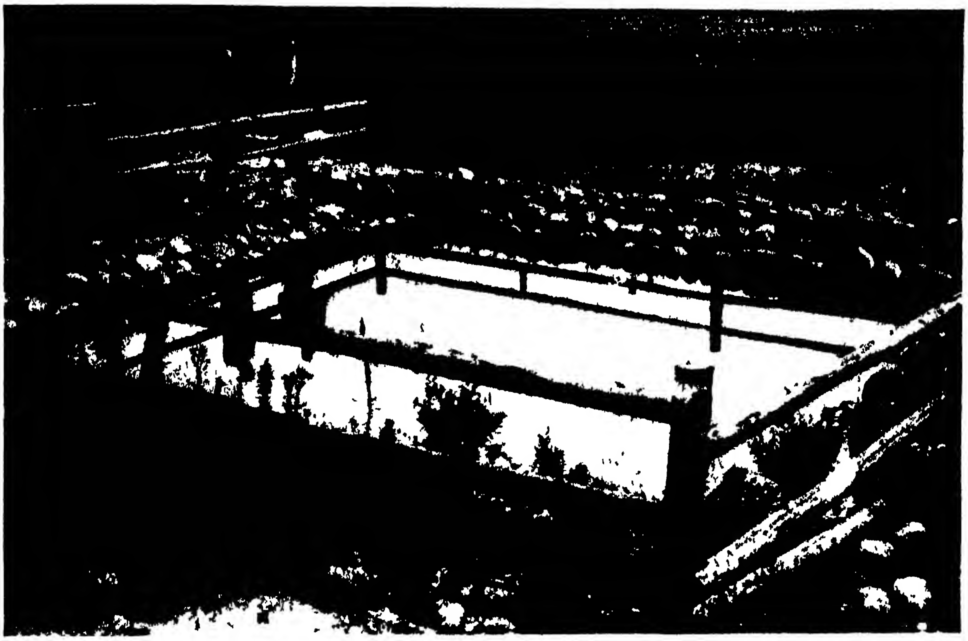
THEY IMPROVED STREAMS FOR FISHING

These range improvements mean better and more stock, and beef, mutton, wool and hides, all of which are needed more in wartime than in peacetime

Americans have become more and more an outdoor people, especially during the past two decades. More and more folks go hunting, fishing, hiking, mountain climbing, skiing, camping or just picnicking This has meant, among other things, better knowledge of the outdoors, of nature, a broader understanding, better health and better citizens Good roads and the auto have helped to bring this about The CCC recognized this fact of American life and built camping spots, picnic grounds, overnight cabins and other outdoor life necessities all over this country. The Corps did landscaping on 233,793 acres, developed 52,319 acres as public campgrounds. It developed 10,398 acres as public picnic grounds. These new developments were widely distributed, in the high mountains, in the foothills and along the seacoasts, they are accessible to the American people.

State parks came into their own through CCC work, 704 camps devoted most of their time to these projects Just a handful of states had any state parks prior to 1933, and those states having parks were able to improve, increase, and develop other areas by CCC labor Now every state has some state parks State, county and municipal park work was done by the CCC in forty-seven states, thirty-five counties and seventy-four municipalities Not only was needed work done on ninety-seven units of the National Park and Monument areas but restoration was carried out on 3,980 historic structures, while to insure accuracy in this restoration work a total of 9,005,407 man-days was spent in necessary reconnaissance and archaelogical investigations by CCC enrollees.

The CCC helped to give wildlife a place in the sun. The Corps built 4,622



THEY BUILT WATERHOLES IN NEW ENGLAND FOR FOREST FIRE PUMPS

fish-rearing ponds, worked on fish food, cover planted and seeded on 112,912 acres, developed 6,966 miles of streams for better fishing, and stocked streams, ponds, lakes and reservoirs with the enormous number of 972,203,910 fish or fingerlings The CCC spent 116,384 man-days on wildlife feeding and built 32,148 wildlife shelters They developed large and small wildlife and game reservations—some brand-new—and enlarged and improved older ones They made game counts and helped mightily on game and wildlife surveys Through Emergency Conservation Work funds, lands for many new wildlife areas were bought and older ones enlarged They planted trees and shrubs on over two and one-half million acres, much of which will serve as habitats or refuges for wildlife. They kept forest fires from destroying wildlife habitats and sanctuaries and even wildlife itself, all over the country And yet there were uninformed critics who said the CCC was ruining the game and wildlife of this nation

In addition to all the above work, the boys did many miscellaneous jobs They built eighty emergency airplane landing fields, 116 radio stations, 532 landing docks and piers, they fought coal fires on public lands in Wyoming for 201,739 man-days, they marked 35,442 miles of forest, park, and other land boundaries During 1941 and 1942 there were 156 CCC companies doing needed national defense work on ninety-two military reservations of the country, thus relieving new soldiers so they could be trained for combat service And with all the above they spent 2,079,440 man-days on emergency work And what might emergency work be? It was work, hard work, on floods, saving people, homes, furniture, chickens and livestock, it was helping clean up and helping stricken humanity after hurricanes and tornadoes, it was looking for and rescuing persons lost in the mountains or forests, it was

BUILT BIRD FEEDING STATIONS

rescuing prospectors, miners, and sheep and cattle during unusual blizzards in the West Some forty CCC camps put in almost two years in cleaning up the debris and making safe from fire the forests of New England after the big hurricane of 1938 Two enrollees were awarded the CCC Certificate for Valor for heroism on forest fires, six received the Award for outstanding work on floods, and twenty-four for heroic rescues of drowning persons Whenever or wherever there were great disasters or emergencies, the CCC was always called on—and they always answered, with supplies, food, and ready and willing hands, arms and backs

These are just a few CCC accomplishment statistics, perhaps meaningless to the average American, but to foresters and other conservationists they stand for the greatest boon ever to come to conservation in this country. When transplanted to the forests, soils, parks, waters and wildlife of the United States—out of a report and onto the ground—these CCC statistics are full of meaning for the future of this nation

Moreover, not only has the CCC taught three million youths through daily practice something of what conservation is, but it has also brought to the American people a better idea of conservation Conservation has become a household word The CCC also gave a new meaning of the word to foresters, soil scientists, naturalists and other conservationists In dollars and cents the value of the work done by the CCC for conservation of natural resources of this nation, in the little more than nine years of its existence, has been conservatively estimated to be well over $2,000,000,000

The Corps built up the bodies and minds and morale of nearly three millions of young Americans against a day of need—which is now—and made them better able and more willing to fight for their country

Almost three million young Americans served in the CCC between the ages of seventeen and twenty-three and thus were of draft age Because of this fact, it is estimated that there are probably two and a half million of them now in the armed forces of the nation, the other half million are probably serving in war industries Thousands of CCC foremen and technicians are now in our armed forces The CCC also gave invaluable training to thousands of regular and reserve officers (60,000 reserve officers served in the Corps) against this same day of need There are thousands of men now better Army officers and many hundreds of thousands of youths now better non-commissioned officers and soldiers because of their training and experience in the CCC. They are better citizens, better Americans, because of the CCC—and America is a better place to live in because of the CCC

VINCENNES: HISTORIC CITY ON THE WABASH

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The character and personality of Vincennes are expressed in the contrast between two buildings standing within a hundred yards of each other and located just southwest of the approach to the new Lincoln Memorial Bridge spanning the Wabash River The first is the old Catholic Cathedral, one of the most interesting historic landmarks of the Mississippi Valley (Fig 1), which has watched the growth and varying fortunes of the city for more than a century (1826) This church, together with the old French burying ground within the churchyard, is representative of a frontier community, yet it has persisted within a few blocks of the business area and thereby lends a picturesque atmosphere to that section of the city Nearby is the other building, the colorful, columnar George Rogers Clark Memorial of modern architecture and design, which stands in a beautiful, landscaped plaza overlooking a broad curve of the river (Fig 2) The latter structure appears oddly out of place in that portion of the city which contains principally architectural types of the last century, nevertheless it represents a spirit of renovation of the urban scene and a tardy civic advancement which appears very much in evidence throughout the community

A River Site

The attachment of a nucleus of population to some riverine site was not at all unusual in frontier America, but the early history of Vincennes is directly related to the military history of the area as well as to the commercial advantages of a river location Its origin was marked by the establishment, in 1702, of a French fort and trading post on the east bank of the Wabash River, 120 river-miles north of the Ohio River[1] (Fig 3) The location chosen was a river crossing, a junction between the Wabash route and a trail leading from the Falls of the Ohio to the St Louis and Kaskaskia settlements Immediately north of the city the river swings to its eastern bluff, cutting between the Robeson Hills and the Indiana uplands a mile to the east, and then winds its way southward to join the Ohio, following a more middle course through the fertile sandy flood plain (Fig 4) This valley plain, about ten miles wide a short distance south of the city, is really a broad alluvial tract that is the product of the Wabash and two of its tributaries, the Embarrass and White Rivers

The immediate site of Vincennes is a Maumee gravel terrace of about a mile in width, extending as an irregular tongue-like projection between the river and the eastern sand hills and bluffs This terrace rises a few feet above the flood plain, but its lower portions have been subject to overflow in cases of unusually high water A sea-wall and newly constructed levee will supposedly remove this flood hazard in the future Except for the leveling of a few historic Indian mounds upon the terrace, no particular building problems have been encountered Back of the terrace small tributary streams of a dendritic pattern have dissected the loessial covered upland into mature valleys and ridges of relatively moderate relief Beyond this gravel remnant, the streams have worked their way through the loessial material that borders the edge of the flood plain and some poorly-drained areas are in evidence upon the broad bottom lands

[1] An unnamed trading post was established as early as 1680, but its permanency is subject to question.

FIG. 1 OLD CATHEDRAL CHURCH
STANDS ON THE SITE OF THE EARLIER ST. XAVIERS LOG CHURCH AND IS SURROUNDED BY AN OLD FRENCH CEMETERY WITH WEATHERED MARKERS

Although Vincennes was originally a river port of importance, that has long since ceased to be the case Very little river traffic has existed on the Wabash for more than fifty years and none has been recorded at Vincennes for at least a quarter of a century The commercial core has expanded to the east and only the older manufacturing plants and secondary structures occupy river-front locations.

The Early City

Vincennes, named after its founder, Frances Morgan De Vincenne, was established as a fort to guard against the encroachment of the English into the territory. A permanent mission dates from the construction of the fort and the community existed in this dual capacity until the territory east of the Mississippi was awarded to England under the terms of the Treaty of Paris in 1763. Then the region was under English domination until captured by George Rogers Clark during the War of Independence The first houses erected around the fort were timber structures, thatched with straw, and plastered with adobe. These cabins were built in "long zig-zag lines with broad verandas and narrow streets between" In 1800 a register of the federal land office was established in this district and the same year Vincennes was made the capital of the vast Indiana Territory with William Henry Harrison, afterwards President of the United States, the first Territorial Governor Governor Harrison's residence, built in 1804 in the style of a Virginia plantation home, was the first brick house in the city and has been retained as an historical shrine and museum The territorial Legislature Hall, a tiny, two-storied frame building of pioneer architecture, once the seat of the capital of a region greater than the original thirteen colonies, has also been preserved and stands among the maples of Harrison Park

The fort remained in good condition until 1816, when it was razed and most of the lumber subsequently used in the erection of smaller dwellings, the greater number in the western portion of the village In the first part of the nineteenth century many handsome brick residences lined the river front a short distance upstream in the vicinity of the present Harrison Park The select residential section of the last century extended along the higher ground from this area of river homes to the Court House on Seventh Street During the building boom of 1888 to 1901 many of the older homes of this section were replaced by dwellings of a more modern architectural design.

The early inhabitants usually followed agricultural or commercial pursuits, the French land grants having divided the prairies around the village into "small slips" so that each proprietor had a frontage on the Wabash River Individual farmers floated their surplus products downstream to the New Orleans market or, more often, a village storekeeper served as middleman, col-

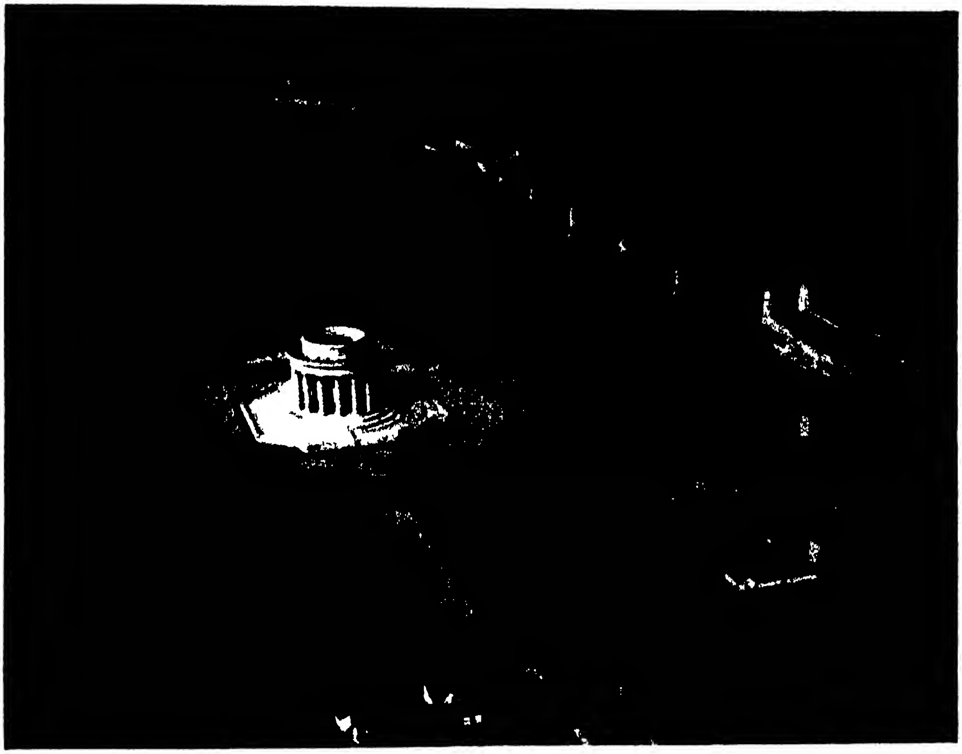

FIG 2. AIR VIEW OF THE GEORGE ROGERS CLARK MEMORIAL ON THE SITE OF OLD FORT SACKVILLE VIEW SHOWS THE WABASH RIVER, LINCOLN MEMORIAL BRIDGE, THE OLD CATHEDRAL WITHIN THE FRENCH BURYING GROUND, THE LIBRARY AND SMALL BRICK CHAPEL USED BY STUDENTS IN THE OLD COLLEGE OF VINCENNES AND ST CLARES CONVENT

lecting the products of the area and transporting them down the Mississippi The necessities that could not be produced in the frontier community were sometimes brought to Vincennes on the return trip from New Orleans but, in most cases, were carried overland from Cincinnati or Pittsburgh or were floated down the Ohio and poled up the Wabash

The Present City

The growth of Vincennes has not been as rapid as that of Terre Haute or Evansville, but its population doubled between 1870 and 1930 It increased gradually until 1900, then more sharply until 1920, but has experienced a retarded growth during the last twenty years (Table I). This continued increase has been, in part, the result of a renovation of community spirit, which has been largely responsible for the increased commercial and industrial ac-

TABLE I

Population Growth of Vincennes

Date	*Population*
1850	2,070
1860	3,860
1870	5,440
1880	7,680
1890	8,853
1900	10,249
1910	14,895
1920	17,166
1930	17,564
1940	18,228

FIG. 3. LOCATION OF VINCENNES

tivity of the city (It was not until almost 1900 that modern industries were attracted to Vincennes) At the present time there are more than fifty industrial and wholesale plants, the majority being small community or service industries Of the remainder, three manufacture straw-board paper and kindred products and two manufacture glass Other important industrial concerns include a shoe factory, a plant making structural steel bridges, a wholesale bakery, a creamery, and a canning factory (tomatoes, apple products and pumpkins) The bridge plant and the window glass company have been located in Vincennes since the turn of the century, but the other major establishments have a shorter history

Vincennes also is a major center of distribution. The wholesale bakery and creamery have been mentioned, the latter having sales branches in some half dozen cities within a thirty-mile radius of the parent processing establishment. An ice and cold storage company has a similar but more extensive system of plants in southwestern Indiana and adjacent Illinois. Wholesale grocers, distributors of bus bodies, mill products, bottled beverages and beer, and the work of the various commission men are indicative of the wholesale phase of the city's economic structure.

Agricultural and Mineral Attachments

Vincennes' early development was based upon a riverine location and the abundant fertile agricultural land of the lower Wabash plain. Later growth has been more closely associated with the nearby mineral deposits along with certain cultural factors

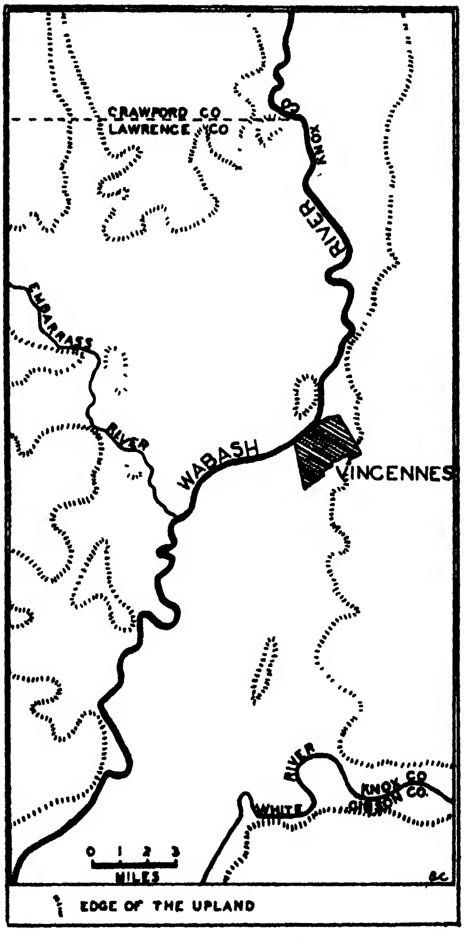

FIG. 4. THE WABASH RIVER
ITS FLOOD PLAIN WIDENS NOTICEABLY NEAR VINCENNES, BECOMING A BROAD ALLUVIAL FLAT.

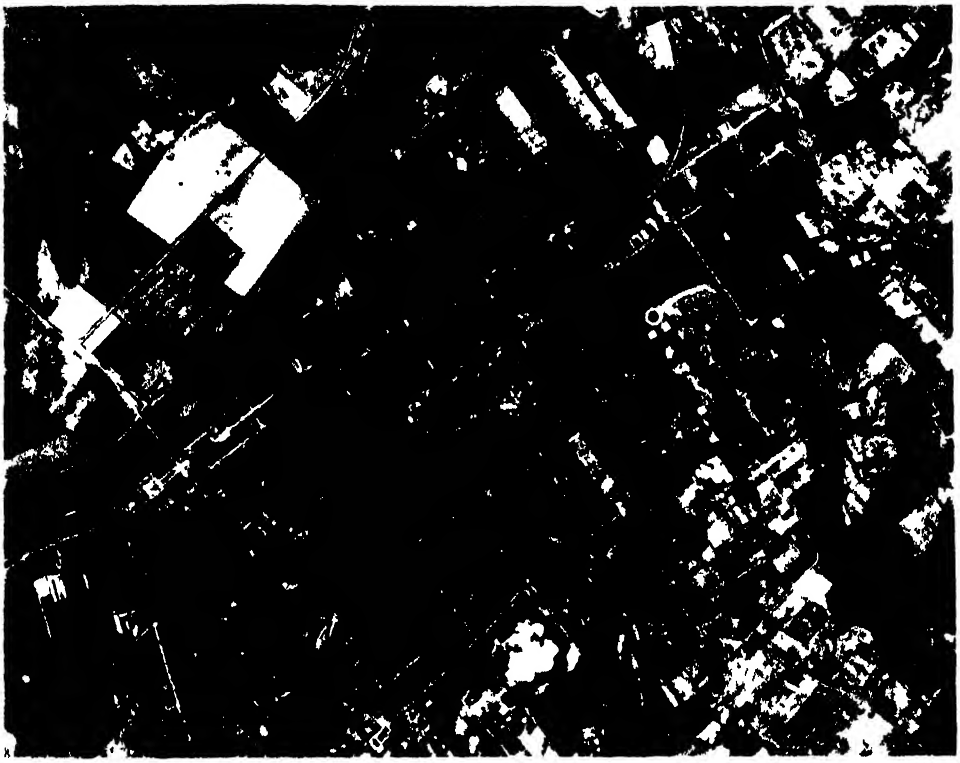

FIG 5 AIR PHOTOGRAPH OF VINCENNES AND ENVIRONS
SHOWING THE RICH FIELDS OF ADJACENT ILLINOIS AND ORCHARDS EAST OF THE CITY

Vincennes is situated in the heart of a prosperous farming region, Knox County, Indiana and Lawrence County, Illinois, being directly tributary to the city Much of the land in these counties, as well as that in Gibson and Wabash Counties directly to the south, is composed of a fertile, sandy, flood plain soil This soil is found in the first and second bottoms of the larger streams and parts of it are low and swampy, necessitating artificial drainage It is a tract of cash grain farms in a mixed farming region with wheat and corn the principal crops The wide expanse of flat bottom land is broken by numerous sandy knolls and ridges, in reality terrace-like remnants of sandy outwash material which are often planted in melons, tomatoes, or sweet potatoes. The famous orchards of Knox and adjacent counties are located on the rolling sand hills (dunes in many cases) at the edge of the upland (Fig 5) The upland portion of Knox County is composed of smooth rounded hills with soft silt six feet or more in depth Wheat, corn, and general farming are practiced on these interfluve areas. Vincennes is connected by rail and highway with metropolitan areas, so it is noted for the shipment of grain, livestock, fruit, and vegetables to the city markets, while local mills and canning factories are a response to the agricultural environment The importance of agriculture in Knox County can best be illustrated by the fact that, in terms of the value of agricultural products, it is in tenth position in Indiana, and the only one of the leading counties that is in the southern third of the state It ranks first in wheat acreage and in peach pro-

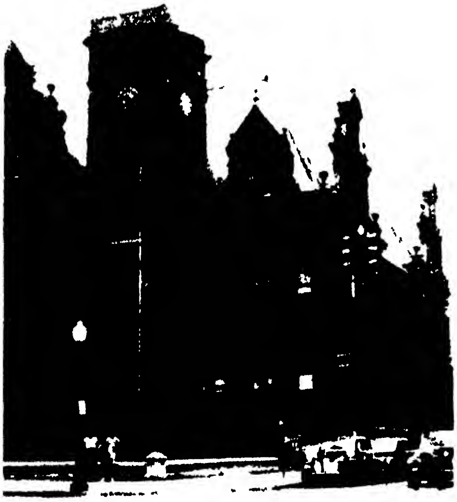

FIG. 6 THE CITY HALL
OLD RED BRICK BUILDING ON MAIN STREET

duction It ranks second in number of apple trees, second in vegetable production, third in tomato production, and is the fourth corn producing county

Two important mineral fuels (coal and petroleum), along with numerous non-metallic construction minerals of less importance, are found near the city of Vincennes Coal has been mined within the corporate limits but the present commercial mines of Knox County are a few miles east of the Wabash River, many of them near Bicknell Coal is an important product in all the counties of western Indiana, Vigo, Pike, Sullivan, Knox, and Greene ranking in the order named Indiana coal is low grade bituminous, its fuel ratio ranking slightly below that of the coal from southern Illinois and western Kentucky.

The older petroleum fields of southeastern Illinois and southwestern Indiana, developed in the early years of the present century, are located to the south, west, and north of Vincennes. These fields also supply natural gas to the cities of the area and the presence of cheap, clean fuel led the Blackford Window Glass Company to locate at Vincennes in 1901 The oil refineries of Lawrenceville and Robinson, Illinois, are only a few miles away. The recent petroleum development in the Illinois Basin, as well as further exploitation in the old fields, have pushed Illinois from an insignificant position (fourteenth) to the fourth ranking oil producing state.

Retail and Wholesale Areas

The axis of the commercial core is Main Street (Fig 7). It includes most of the retail district which serves the urban community, the outlying rural areas, and, in part, the neighboring mining and agricultural cities. On this old thoroughfare are situated the principal retail stores, banks, office buildings, theatres, and the city hall (Fig 6), which is a center of municipal importance in any American city It is characterized by buildings of two or three stories in height, although this general level is exceeded by a six-story office building and a half dozen intermediate structures (Fig 8) Brick is the prevailing material with stone of secondary importance, while the architectural types are characteristic of the past century with an intermingling of more modern structures These downtown buildings, facing each other across the narrow, crowded street, present a scene which, in its essential characteristics, can be duplicated only in the older cities of the United States.

The commercial development has expanded to include parts of the adjacent parallel streets (Busseron and Vigo) and two cross streets (Second and Seventh) more or less at the ends of the principal district (Fig. 9). Busseron Street has a few retail stores but is characterized principally by service shops, while Vigo Street has commercial structures (principally garages and service stations) interspersed among residential structures. Second Street is lined with old buildings and is a mixture of manufacturing, wholesale warehouses,

FIG 7 MAIN STREET LOOKING TOWARD THE RIVER FROM FOURTH STREET

secondary retail establishments, and a few vacant buildings Seventh Street connects the downtown area with the Union Station, about three-fourths of a mile east of Main Street It is a street occupied by commercial, residential, and public structures, the latter including the Court House, Public Library, and Civic Auditorium Probably its development has reached a point of stagnation for the only street car line leading to the eastern part of the city was removed from this street about ten years ago, and now most modern vehicular traffic follows the highway a block nearer the river.

The wholesale district occupies the older part of the city and much of it is to be found along North Second Street which was once a flourishing retail district Since the better retail stores have moved to more desirable locations, this part of the city, for the most part, shows unmistakable signs of decadence, with a few of the buildings now unoccupied or at least only partially utilized The buildings are of brick construction, there being a complete absence of corrugated iron sheds and other typical warehouse structures This wholesale function of Vincennes is not a recent one, for the city has always been one of the important railway and highway junctions of southwestern Indiana

Industrial Activity

Vincennes is and always has been a city of varied industrial activity A century ago the flour milling and woodworking industries were of foremost importance and the city has never failed to have several representatives of the former Flour milling reached its peak in the latter part of the nineteenth century and the early part of the twentieth, when four or five mills were in operation most of the time The largest, Broadway Mills, had a daily capacity quoted at various figures ranging from 200 to 350 barrels, and the quality of its flour was recognized when the mill was awarded first prize at the Philadelphia Centennial Exposition in 1876 The mills of Vincennes supplied foreign as well as domestic markets during this period, and as late as 1910 much of the flour from Atlas and Emison Mills was shipped directly to Glasgow, Scotland. Meatpacking, based on locally supplied swine and cooperage and salt from southeastern Illinois, flourished prior to the Civil War, but has long since passed from the

FIG 8 PLAZA BETWEEN FIRST AND SECOND STREETS
SOME OF THE BUILDINGS IN THIS OLDER SECTION OF THE CITY WERE REMOVED TO MAKE THE APPROACH TO THE LINCOLN MEMORIAL BRIDGE AND THIS PLAZA AREA IN DOWNTOWN VINCENNES

industrial scene The cooperage plants and furniture factories of the last century were a direct response to the abundant hardwood forests, but there is little saw timber left in the area and lumber products are no longer important In the present century a rolling mill and a button factory added to the variety The former was discontinued with the obsolescence of its equipment and the latter with the decline in the quantity of mussels taken from the Wabash River, although the recent economic depression may have been a contributing factor The bridge plant and a small foundry are the only remaining representatives of the steel industry The willow furniture factory recently discontinued the line and began manufacturing and distributing bottled beverages. The canning factory and a few minor establishments are seasonal in their operation and the mills are not large employers of labor; hence, the major portion of the industrial wage earners are employed in the shoe factory, the glass industry, and the paper plants.

Of these three industries, the shoe factory is the largest employer of labor This plant is the result of the decentralization of the shoe industry and is one of many similar factories located in cities of five thousand to twenty-five thousand population within a two-hundred mile radius of St Louis, the shoe center of the Midwest The prime requirement for the location of these branch plants is that there be convenient transportation facilities between the city and the St Louis warehouse of the parent establishment

The manufacture of strawboard is not a new industry at Vincennes, one plant having begun operations in 1886 and a second in 1904, but it is only within the last two decades that the industry has become important. This increase can be traced to two factors: the increasing demand for strawboard containers and the trend from the manufacture of one major product to the manufacture of a variety of items Twenty-five years ago egg-case board was one of the common products, but it has now become of only secondary significance Strawboard

wrapping paper and cardboard containers are of greatest importance today, but a comparatively new product, chip paper, is becoming relatively more important In general, the major portion of the output is marketed in the nearer large cities The Vincennes plants are conveniently located because they have immediate access to the two principal raw materials, the wheat straw of the lower Wabash Valley and the cheap coal of western Indiana

The principal glass factory was moved to Vincennes in 1901 solely because of the cheap natural gas that was available None of the other raw materials has a local origin The sand comes from Greencastle, Indiana or Ottawa, Illinois; the limestone from Bedford, burnt lime from Ohio and elsewhere; and soda ash from Detroit

Cheap land and accessibility to lines of communication are the chief factors in determining the location of the industrial districts within the city. These conditions are found on or near the urban periphery and are, in some instances, low, swampy lands not suitable for residential utilization One group, glass and paper, is located just beyond the southwestern corporate limit near the city drainage ditch and only a block from the river (Fig 10). A second group is in the eastern part of the city not far from the union station and near a junction of rail lines The third district is less concentrated and extends along the river from the downtown section to the northern limits (Fig 11) The last named area contains many of the older establishments and, being interspersed with residences, is somewhat handicapped from the standpoint of expansion of plant capacity or loading facilities The numerous light industries are scattered in various positions throughout the city but chiefly on the periphery of the commercial core or along the railroads

Residential Districts

The character of the Vincennes residential areas varies with the suitability of the land and its desirability for residences The land to the south and west of the city is low-lying and swampy, so the principal residential areas are found east of the commercial core The select residential district of earlier days was on the higher land conveniently accessible to the downtown area This was along North Fifth, Sixth, and Seventh Streets and the large colonial type structures remain to attest the former prestige of this section of the city Some of these homes are currently utilized as tourist homes and the more desirable rooming houses The newer and more select additions of the present decade are along the edge of the bluffs and several blocks from the earlier district This area is more rugged and offers greater opportunity for beautifully landscaped

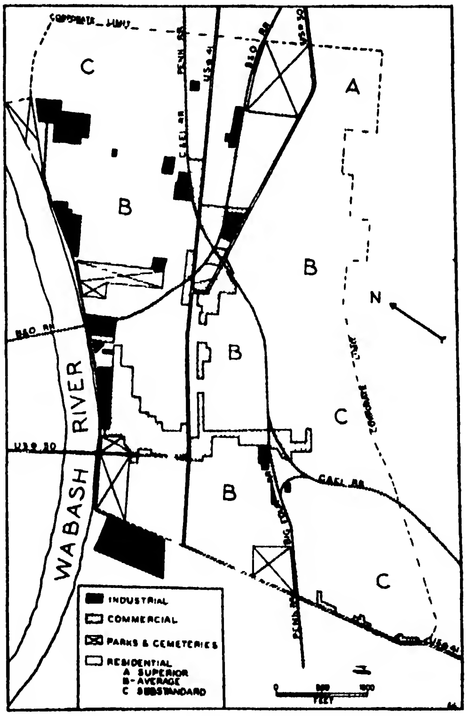

FIG 9. MAP OF VINCENNES

FIG. 10. BEYOND THE WEST CORPORATE LIMIT
LOW, SWAMPY CONDITIONS PREVAIL. IN THE BACKGROUND CAN BE SEEN THE PLANTS OF THE FORT WAYNE CORRUGATED PAPER COMPANY (LEFT) AND THE BLACKFORD WINDOW GLASS COMPANY.

homes It is also well away from the city proper which is the case of most recently developed subdivisions Between the two areas is an irregular section of middle class homes The substandard homes are found in the northern sector and in the south and southwest portion of the city, although these are usually individual homes rather than multiple dwelling units (Fig 8) Most of the Negro families live near the southwestern corporate limit

Most of the residential structures have not been built within recent years; in fact, there has been very little construction work at Vincennes since 1930. The major building boom was between 1895 and 1905, the period of greatest industrial expansion, when thirty-one per cent of all residential structures were built Thirty per cent of the structures were built before 1895 and several are more than a hundred years old. This leaves thirty-nine per cent. that have been erected since 1905, construction gradually declining since that date [1]

Some years ago Vincennes had a slum problem. The low land along the river in the western part of the city was the home of the mussel fishermen and appropriately named "Pearl City" It was characterized by squatter shacks and the accompanying filthiness These homes were on the very edge of the river and subject to occasional flooding With the decline of mussel fishing the families were destitute or near-destitute most of the time Then, prior to the construction of the new levee, a combination municipal and private housing project was undertaken and these people were encouraged and persuaded to move into the more desirable accommodations and to seek other types of employment. A second slum area was located near the northern corporate limit but, after many of the buildings were condemned, a low-cost federal housing project, Major Bowman Terrace, was built (1940) and many of these people moved into the modern two-family units that had become available (Fig 12).

Relationship to Larger Cities

Vincennes is related to the nearer large cities but is not solely dependent upon any one of them According to Dickenson it is situated near the edge,

[1] *Real Property Survey*, Vincennes Housing Authority, 1939, p 21.

but within the Chicago metropolitan region, that city being the geographic epitome of the Middle West [2] The people of Vincennes read Chicago, St Louis, and Indianapolis newspapers, those of the first named city predominating Livestock shipments are sent to these same cities and also to Cincinnati, but St Louis appears to be more important Vincennes is within the wholesale trade territory of Indianapolis, but near the boundary of that territory with those of St Louis and Chicago Terre Haute and Evansville are smaller but nearer wholesale centers of importance

Conclusion

The prestige of the city, its traditional leadership in the region, and superior transportation facilities have combined to give Vincennes a significant position in the commercial life of southwestern Indiana. The list of wholesale firms include the distributors of groceries, petroleum products, bus bodies and equipment, feeds and flour, bakery products, lumber, and hardware Commission men buy livestock, poultry, fruits, and vegetables from the producers and ship them to metropolitan markets. The retail merchants serve not only their own community, but also the occasional and frequent customers from neighboring cities, nearby villages, and the surrounding farming regions of Indiana and Illinois.

To summarize, Vincennes as a city possesses a unique quality that distinguishes it from most other communities of southwestern Indiana This may be attributed to the diversified economic interests of the community, its somewhat larger size, and the ease of communication it enjoys with the other urban centers of southern Illinois and Indiana. Vincennes is not a mining community although mining has long been a major industry in this part of the state and the proximity of cheap coal has contributed to the varied industrial structure of the region The city is within an area that

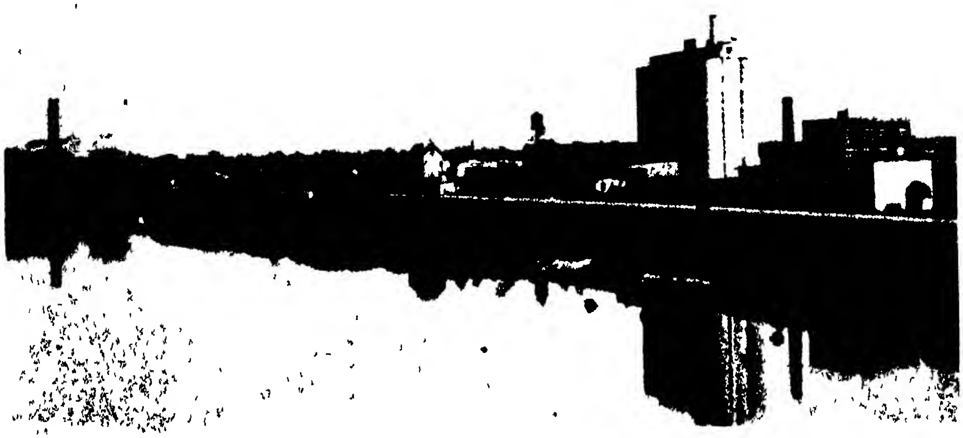

FIG 11. THE ATLAS MILLS BESIDE THE WABASH

IN THE OLD PART OF THE CITY NOW PROTECTED BY THE NEW SEA WALL IN FORFGROUND *Left:* THE MUNICIPAL WATER TOWER AND SLENDER SMOKESTACK OF CENTRAL FIBERS CORPORATION.

[2] R. E Dickenson, "The Metropolitan Regions of the United States," *Geographical Review*, Vol 24, 1934, p. 286

FIG. 12. MAJOR BOWMAN TERRACE
A FEDERAL HOUSING PROJECT COMPOSED OF TWO-FAMILY UNITS WITH INDIVIDUAL YARD SPACE

ranks high agriculturally, but is not a city that is dependent upon the adjacent farms and orchards for its existence Manufacturing is important, but there is not a single outstanding industrial plant in Vincennes In brief, it has retained its position of regional leadership because of diversified endowments and because it had the advantage of an early start Except in a few instances, Vincennes does not depend on the surrounding rural areas which, instead depend on Vincennes, both for day-to-day and seasonal purchases

The general impression received is that Vincennes is a center of declining importance In some respects this is true, for the purpose of its earlier existence is gone The small unimportant industries that are existing only because of an early start or because of some previous advantage which no longer exists can hardly be sufficient for Vincennes to retain its position as a regional center However, there are industries, such as corrugated paper, that can be manufactured in Vincennes as cheaply as, or more cheaply than, anywhere else Others, such as shoes, although enjoying no special advantages, can compete successfully under present conditions It appears quite possible that, supported by moderate civic enterprise, the city need not anticipate a dark future, but can look toward continued leadership, even though on a moderate scale

SCIENCE, EDUCATION AND CHINA'S RECONSTRUCTION

By Dr. CHI-TING KWEI

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WHEN China was invaded in July, 1937, Japanese militarists boasted that we would be brought to our knees in three months. It is now fully six years and China is fighting on, more determined than ever to win the victory on the side of the United Nations. Our endurance is largely due to the far-sighted policy of our leaders to carry on reconstruction side by side with our war of resistance.

Before the war, western China was almost entirely undeveloped, as compared with the coastal provinces. Therefore, for military reasons as well as for the reconstruction of our industries, it was imperative to build up a comprehensive system of transportation, besides the existing water routes. China immediately mobilized labor, including 100,000 women in the Kansu province, to build her highways. Up to June, 1942, 79,827 kilometers (over 49,000 miles) of highways have been built, often over difficult terrain with dangerous cliffs or over ground covered with snow part of the year, as in the case of the Burma Road or the road from Loshan (Kiating) to Sichang. Two of the important lines are the Chinese Soviet Highway and the Road from Chungking to Rangoon. The former connects Chungking to Tachen via Sian, Lanchow, Sinsinchia and Urumchi over a distance of 3,451 kilometers. The total distance from Chungking to Lashio via Kunming and thence

AN OPEN AIR CLASS NEAR A TEMPORARY SCHOOL BUILDING

GIRLS OF LIANGKIANG GIRLS' COLLEGE

THESE YOUNG STUDENTS HAVE TREKKED FROM SHANGHAI TO CHUNGKING TO CONTINUE THEIR STUDIES. THEY HAVE LEARNED TO USE PICKAXES, BUILD THEIR OWN ROADS AND DORMITORIES.

over the Burma railroad to Rangoon is 3,360 kilometers.

During the war, China has extended her railways into both the north and southwestern provinces. The Lunghai Railway has been extended from Sian to Paochi and the Hsiang Kwei Railway has been completed between Hengyang, a point in Hunan Province on the Canton Hankow Railway, to Kweilin in Kwangsi Province and thence to Kweiyang in Kweichow Province. Ultimately there will be a railway running parallel to the highway between Kweiyang to Chungking, our wartime capital. With the supply of Oregon pine and rails cut off from abroad by the enemy's blockade, our engineers are working under great difficulties but with much ingenuity. Local materials are being used to the fullest extent and much of the old railways has been dismantled and transported to the hinterland just in advance of the enemy's occupation. Thus Hsiang Kwei Railway (Hengyang to Kweilin) may be considered in part as a bodily transplantation of the Cheh-Kan Railway (Hangchow to Nanchang). The railways in Free China now total 2800 kilometers.

With the loss of the coastal provinces, China's loss in industrial plants was extremely heavy, such as the sugar refinery and the salt and soda works in Tientsin, chemical factories for producing ammonia, ammonium sulphates and acids in Nanking, and numerous textile, soap, glass and rubber factories and shops in Shanghai. But a serious effort has been made to help 42,000 skilled laborers and technicians to move into the interior and to transport some 12,000 tons of machinery. Both men and machines have been gradually augmented, so that

today it is estimated that some 3,000 factories[1] are in operation, including power plants, paper, cement, textile, steel, oil, sugar and alcohol factories. To insure safety from bombing most of the factories are made of small units, often disguised under thatched roofs so as to make them indistinguishable from the surrounding houses. This is not economical, but we have to wait until the end of the war to make adjustments.

To increase food production, as well as to provide relief for refugees, much has been done to provide irrigation for otherwise wasted land. Most of the irrigation projects are completed or in the process of completion in Shensi, Yunnan, and Szechuen provinces. Altogether there are 258 such projects to provide water for 335,000 acres of land. Also, the substitution of cereal for opium planting is expected to give us an extra crop of 25 million piculs of rice. (One picul is equal to 133⅓ lbs.)

Recent prospecting has given us satisfactory results. Before 1939 nobody suspected that China had oil outside of Manchuria, but this year the oil wells in Kansu Province are expected to yield 5,000,000 gallons of gasoline, 2,500,000 gallons of kerosene and 1,200,000 gallons of crude oil. Likewise, we have discovered tin in Yunnan, manganese in Kweichow, asbestos in Western Szechuen, as well as coal, iron and copper in varying amounts.

A little south of Kiating, the water power from the difference in the levels of the Tatu and Min rivers is being harnessed to provide eventually all the needed electrical power within a radius of 250 miles. For the careful planning and bold execution of China's industrial reconstruction, we are indebted to the National Resources Commission and the Ministry of Economics.

Realizing that the universities train leadership, which is the backbone of our resistance, they have never been spared in Japan's wanton destruction.[2] Thus Nankai University, like Louvain, will be remembered in the history of twentieth century vandalism. For the same reason, the Chinese government has been doing everything in its power to preserve these universities by moving faculties, students, libraries and equipment into the far interior at a time when military necessities caused extreme congestion in transportation.

Just before the Japanese invasion, in 1936, we had 108 higher institutions of learning with a total enrollment of 41,609 students. The dislocation due to war reduced the number of colleges and technical and professional schools to 91 in 1937. But in spite of our loss of jurisdiction in enemy occupied territories, the number of institutions increased in 1941 to 132 with a total enrollment of 57,832 students.

Practically seventy-five per cent of the total enrollment are refugee students, that is, students whose homes are in the occupied territories or whose families have been crippled financially due to the exigencies of war. The first group walked westward for the most part just in front of the enemy's push in 1938, carrying books and bundles under their arms. These have graduated from the institutions and are absorbed in our war and reconstruction projects. Their successors today are the young boys and girls of high school and college age who steal across the enemy's lines from occupied territories and march hundreds of miles on foot, facing hunger, thirst, sickness and uncertainties enroute to freedom and learning.

For these refugee students, the government has to provide for food and lodging as well as for instruction. The

[1] By the end of 1940, there were 1,354 factories, distributed as follows: mechanical shops, 312; mining and metallurgical, 97; electrical, 47; chemical, 361; textile, 282; and others, 259.

[2] The total loss for educational institutions of all grades from somewhat incomplete returns is Chinese National $252,105,425, or roughly U. S. $72,000,000 at the pre war rate of exchange.

GIRL STUDENTS BUILD A NEW CAMPUS AFTER BEING BOMBED OUT

pre-war cost for food for each student was about $4.00 a month. Today it is about $200 per month in Chinese currency. Still about twenty per cent of them need further help to provide for bedding, clothing, books and other educational tools. This has come partially from the Chinese government and partially from American students through the instrumentality of student Christian Associations and United China Relief.

During the war years, there is a distinct increase in the interest of the students in applied sciences as compared with arts. Table I gives data obtained by the Ministry of Education on courses chosen by students before and during the war.

Of the various branches of engineering, civil engineering was most popular at the beginning of the war, but after the Burma Road was closed, mechanical and chemical engineering took its place and will likely continue to be popular as China develops her industries.

While enrollment in the technical courses are steadily on the increase, the rate of increase in the supply of teachers from men returning home after completing their education abroad is reduced because of the cost and difficulty of transportation. This condition is made worse by the fact that many men have been taken from the universities to be put in the factories, at road building and on other projects. We are, therefore,

PERCENTAGE ENROLLMENT IN COURSES

	1936–37	1940–41
Arts	20	11
Law, Political Science & Economics	20	21
Commerce	8	10
Education	8	9
Natural Science	13	12
Engineering	17	21
Medicine	8	8
Agriculture & Forestry	6	7
Others	0	1

A UNIVERSITY SCIENCE LABORATORY DEMOLISHED BY BOMBING

fully aware that we are in great need of well-trained men The absorption of our graduates into the industries creates a similar dearth of middle school teachers

The Chinese Society of Engineers is a prosperous and going organization Its annual meetings have in recent years been held in Chengtu, Kunming, and Lanchow, and each has been attended by over one thousand persons At such meetings, technical papers are read before its various sections, and general discussions have related to China's program for reconstruction in so far as engineering is concerned Such meetings have done much to arouse popular interest The three past presidents of the Society have been Dr Wong Wen-Hao, for many years head of China's Geological Survey and now Minister of Economics, Mr. Chen Li-Fu, mining engineer and present Minister of Education, and Lin Hung-Hsun, China's leading railroad and highway engineer. Delegates are given travel subsidies or are provided with transportation as a measure of encouragement, partly because travel is very expensive today and partly because engineers are encouraged to visit widely scattered centers of potential industrial importance

The Science Society of China is an older organization It was founded by a group of Cornell Students in 1915, including Dr Hu Shih, Dr. Y R Chao and Mr H. C Zen For many years the Science Society also held annual meetings at widely scattered places. The Society publishes *Science*, *Science Graphic* and *Proceedings* of the Society, which in no small degree disseminate scientific knowledge effectively among Chinese youth. Before the war, the Society maintained an excellent printing press in Shanghai and a museum and a research laboratory in biology in Nanking. In the early thirties, branch societies were formed, such as the Chinese Physical Society, the Chinese Mathematical Society, the Chinese Chemical

Society, and several organizations of biologists, each of which maintains one or more publications.

Since most of the members of the Science Society and its branch societies come from the ranks of teachers and workers in research institutions who have been seriously affected by the high cost of living ever since the third year of the war, attendance at its annual meeting is mostly from one geographical region, although papers are contributed by members elsewhere who cannot attend the meetings in person Last summer the Chinese Physical Society initiated a new type of annual meeting in which meetings were to be held simultaneously in six places Actually, they were held in four places, Kunming, Chungking, Chengtu and Kweilin Forty papers were read at its 1941 annual meeting in Kunming In 1942 there were altogether seventy-two papers The nature of the papers varied from the practical measurement of the susceptibility of mineral rocks to a theoretical treatment of the thermodynamics of a living cell

Chinese scientists as a whole have focused their attention on practical problems in order to help in the war effort The chemist has cracked Tung Oil to give us synthetic gasoline; the biologist and the soil scientist have made thorough study of kinds of soil, the regional distribution and deficiencies to be made up by special fertilizers; the physicist and the electrical engineer have helped in the production and maintenance of electrical communication and power, the geologist has been telling us where to tap for natural resources; and the mathematician has helped in our war efforts by work on ballistics. But still there is strong evidence of interest in pure science There are men working on the "Omni-Range Electrical Forces and the Static Nuclei," and on the "New Skulls of Mammals of Probably Upper Triassic Age in Yunnan." As another good example, we may take the astronomical expeditions to Lintao, near Lanchow, and to Chunan in Fukien province, not far from the enemy lines, to observe the solar eclipse of September 21, 1941 (The last mentioned expedition failed on account of bad weather)

Lastly, I must pay tribute to my fellow teachers and research workers in China Most of them are refugees They have lost much earthly goods because of bombing, expensive travel, and inflation They and their families are poorly fed and clothed and have to do much physical labor that a mechanized civilization can never appreciate But they are joyously training the younger generation and sharing their hardships, and eagerly doing their part to search after truth and to help in the reconstruction of their homeland so that she may become a worthy member in the family of nations

FRANK JULIAN SPRAGUE, 1857–1934

By Dr DUGALD C. JACKSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

It was natural for Frank Julian Sprague to pioneer The story of his life responds to Walt Whitman's lines.

> All the past we leave behind,
> We debouch upon a newer mightier world, varied world,
> Fresh and strong the world we seize, world of labor and the march,
> Pioneers! O pioneers!

Sprague was a "man o' independent mind"

He was not only a pioneer, but he also was one of the few among the world's population who see in the mind's eye the character and results of proposed revolutionary physical embodiments Guided by such mind's images, he truly set the patterns of many factors in our present industrial and urban life

The philosopher William James wrote in one of his essays· "Mankind does nothing save through initiative on the part of inventors, great and small, and imitation by the rest of us—these are the sole factors active in industrial progress Individuals of genius show the way, and set the patterns, which common people then adopt and follow" Where he used the word "inventors" I understand him to have intended it to be interpreted broadly in all kinds of creative effort In physical invention Sprague was a genius and his productions and plans have been adopted and followed in world-wide distribution. The sign "no thoroughfare," which is in common acceptance, never cried pause to the iconoclastic mind of Sprague when he was set on producing a through passage; and the world has followed with satisfaction in paths where he led. At the end of a brief outline of his romantic career written in 1934, he himself said of his active life, "The three score years have been those of a ready acceptance of any challenge in electrical engineering progress, a mental elixir which has made life worth living in the effort to add to human progress and comfort, the zest for which advancing years have not entirely abated"

Born on July 25, 1857, at Milford, Connecticut, he was of the ninth American generation from his paternal English forebears His father was in the business of manufacturing hats On the death of his mother, in 1866, he and a younger brother fell under the guidance of a maiden aunt who was a school teacher at North Adams, Massachusetts, and there he attended school In 1874, on the advice of his school superintendent, he entered a competitive examination for a cadetship in the United States Naval Academy He won the appointment and graduated in 1878, well placed in a class of notable graduates

Individuals usually are in bondage to the ideas in which they have been immersed since birth, but not so Sprague He was born with a restless and creative mind The announcement in 1876 of the invention of the telephone by Alexander Graham Bell, followed by outlines of work in the same field by Gray and Edison, fired his imagination His interest, however, rested more particularly on the possibilities of electric power The year previous to his Naval Academy appointment there had been announced those experiments on the reversibility of the Gramme dynamo at the Munich Exposition of 1873 which awakened the world to the possibilities of electric power; and Sprague never lost the sense of impulse with which that announcement fired him.

He was never happy with an uncompleted task. Poetic fervor drove him toward completion. With his course di-

FRANK JULIAN SPRAGUE AT SEVENTY-FIVE YEARS OF AGE.

rected by his highly skilled mind, the excitement of a powerful idea did not divert him onto false trails. Each great creative discoverer or inventor, in proportion to his achievements, to again revert to quotation from the wisdom of William James, approaches the ideal expressed by the words, "The union of the mathematician and the poet, fervor with measure, passion with correctness, this surely is the ideal." Sprague, although without the spirit of the introspective philosopher, exemplified this ideal.

While aboard ship, after his graduation from the Naval Academy, he seems to have given some concern to his chiefs

and his associates by the force of his desires to invent and improve. He had been stirred by the report of the United States Commissioner of Patents in 1849, that contained eloquent words of prophecy regarding applications of electric power which few of the period thought valid, and his spirit of invention was afire.

He had visited the Centennial Exposition of 1876 in Philadelphia while a midshipman at the Naval Academy and been elevated in heart by much that he saw there, as were other youths who later became, like Sprague, well-known in engineering and the engineering industries. To accomplish important ends a man must be polarized so that he tends constantly toward his goal, and visits to the Centennial served that purpose for many young men of ability.

Indeed, the Centennial Exposition was a stimulant in the education of a nation wherein men might independently enterprise, build and produce, to their own benefit, but with due consideration of the welfare of their fellow citizens and their fellow-men throughout the world. Individualism as a clearly defined quality arises only when man recognizes himself as a social animal In all this Sprague's mind was well directed.

During the two years after graduation from the Academy, he followed the life of a young naval officer, including a period on the Asiatic Squadron at a time when the tragedy and depression of war were not there; but, individualistically, a personal "Midshipman's Notebook" which he kept became filled with memoranda regarding inventions, ranging from telegraphs and telephones to devices for controlling racing of ships' engines. If the clock's ticking off its minutes does not stimulate the lazy, weary or ambitionless man to accomplishment, the rolling years ultimately will overtake him while he is yet empty-handed; but the years had no such reproach for Sprague, for he always maintained himself in fruitful reflection and employment. He depended on thought-directed exertion, and not at all on wishful or indolent thinking. His mind, "like water, willy-nilly flowing," was constantly pushing forward into new and fruitful ideas. Before his life was over, he could well repeat after the poet:

"I have stolen the eggs from the phoenix' nest
And walked by the shores of the Ocean-Sea"

Ordered home in 1880 for examination, he secured a short leave which was dedicated to experiment on an arc-lamp mechanism at Stevens Institute of Technology. But of particular note is the opportunity which he there had to meet Professor Henry Draper (physiologist, chemist and astronomer) and those two pioneer experimenters and inventors in the electrical field, William Wallace and Moses G Farmer, all widely renowned for their achievements. Sprague's later memories of the meeting with these three men show that shaking their hands and talking with them stirred him mightily. He then was twenty-three years old and already possessed a boiling enthusiasm for invention in the scarceborn field of electrical engineering, of which the problems sparkled before him like stars in the sky of a clear winter night.

Ordered to duty on a training ship for boys, whose tuition as sailors did not much interest him, he planned to install electric lights for the ship using extemporized and borrowed equipment, but his effort at borrowing was unsuccessful. This training ship put in at Newport. There he again met Professor Farmer. He undertook the construction of a novel dynamo and a control switch in the intervals of ship duty.

Naval life in those days was quiet, and he asked for an assignment as assistant to the officer representing the Navy at

the Paris Exhibition of 1881. This request being disallowed, Sprague secured orders for temporary duty aboard a ship being fitted up to become the flag ship of the Mediterranean Squadron, associated with the opportunity of three months leave on arrival at the station. The ship was delayed in sailing (during which time Sprague, incidentally, installed a call-bell system aboard, constructed out of such materials as were available), and when it finally arrived the date was too late for the Paris Exhibition, but he was given the privilege of attending the Crystal Palace Exhibition of London, which was then in progress with great acclaim. A competent engineer without objective duties becomes homesick for action of either mind or muscle Sprague never permitted himself to suffer from such homesickness His was a life of vision sauced with discretion.

Arrived at the Crystal Palace, he was made a member of the preferred section of the Jury of Awards and secretary of the section; and thus at twenty-five years of age he became associated with some of the leading scientists of Great Britain. This was (as he expressed it) one of the most colorful phases of his life. In this position he initiated a series of tests of gas engines, dynamos and electric lights As he extendedly overstayed his leave, he received peremptory orders to rejoin his ship. There he made out an elaborate, well illustrated report which ultimately was published as a United States Naval Professional Paper of 169 pages plus charts and diagrams. This received the commendation of the engineering world in England and America. It was during these tests that features of gas engine indicator diagrams led to operating a sixteen horsepower Otto engine on a forced test with the outside ignition cut off and with only compression firing: that, as he has said, was "a recorded experiment which may be considered the forerunner of the Diesel engine."

Offering his resignation from the Navy, in which he held an ensign's commission, and with a year's leave of absence in his pocket, he made an arrangement to enter the employment of Thomas Edison as an expert assistant But before returning to America he went to Manchester, England, to test the then newly improved Edison dynamo designed by Edward Hopkinson and to report on the conductor economy derived from using Edison's three-wire system for distribution of electric current. He arrived at home on the celebrated day of the opening of the "Brooklyn Bridge" (May 23, 1883) and was soon sent out to install Edison electric plants

The poet Horace says of Hebrus (in Conington's paraphrase):

> When the deer are flying blindly all the open
> country o'er
> He can aim and he can hit them; he can steal
> upon the boar
> As it crouches in the thicket unaware.

This we can interpret in application to each truly great engineer and inventor. When he puts his hand to a project, however great its difficulty, he successfully carries through. The problem of establishing a process of calculating cross-sections of the copper feeders and mains for Edison three-wire distribution systems, to substitute for the use of diminutive models, was assigned to Sprague. He solved this, and the time required for a lay-out was reduced, says Sprague, from a fortnight "to about four hours." He always correctly ascribed the feeder and main system of constant-voltage distribution to the genius of Edison, but his own arrangement was patented on an application filed on September 19, 1885, and assigned to the Edison Company. Sprague's arrangement comprised the now long-recognized plan of feeders of resistances inversely proportional to the loads they were expected to carry, along

with feeder regulators to compensate for varying conditions of load.

Yet the true engineer absorbed in the fascinating fields of invention is not only interested in his own environment or his own time like a painter, but like a poet is also a prophet. Sprague's eyes were always set beyond the day's work. His intellectual courage and inventive fire brooked no horizon. His brilliant achievements were incubated by mind and thereafter reduced to physical realization for others by means of his experiments. To him the embodiment was realized when the mind painted the picture; and on the picture he would stake his reputation and future Such qualities require powerful thinking, which is an individual, personal phenomenon and its successful prosecution depends upon the intellectual power and the will of the thinker—qualities that Sprague possessed in high degree. And here we can agree with Rochefoucauld when he says that it is from want of application rather than of means that men fail of success. It was mental application that won for Sprague

His mind was filled with a vivid picture of the future usefulness of the electric motor, which at that time was yet a feeble infant as far as essential usefulness was concerned Therefore in 1884 he left his post of employment in the electric-lighting business with Edison and, on a shoe string, started a company of his own called the Sprague Electric Railway and Motor Company. Men lived rapidly in electrical engineering in those days, and Sprague was constantly doing unexpected things. Electrical engineering was not yet called by that name, and few were cultivating the art. Sprague belonged in electrical engineering to the generation of Edison, Weston, Elihu Thomson, Brush, W. Siemens, Mordey, John Hopkinson and a few other great pioneer inventors. To him, engineering invention was a career thrust upon him to absorb his whole soul; but also to be thoroughly enjoyed. His was an enthusiastic, stormy disposition; but he was a tireless worker, both mentally and physically, when his eye was on the ball; and his company was soon making an enviable reputation for the originality, initiative and courage of his work. From his company came, I think, the first electric motors of importance installed in industrial service west of the Missouri River and certainly, for that day, the largest fed from commercial electric currents in the West.

It was in the Autumn of 1884 that the Franklin Institute organized an electrical exhibition in Philadelphia, which was an enterprise of importance for its day The new company exhibited several of Sprague's inventions and he frequently was a personal attendant at his exhibit where he extolled with emphasis and enthusiasm his self-regulating, constant-speed, direct-current motor, in which the constancy of speed as the load varied was secured by a differential series-winding on the field magnet It was in this year that the Sprague Electric Railway and Motor Company had been established and Sprague now was fully launched on his great career of invention and promotion in the electric traction and associated fields.

His progress in invention and exploitation took on a tremendous pace The constant-speed motors rapidly found a place of importance in daily use, although electric power stations and electric distribution circuits were still young and of limited extent in our cities Our present-day commonplace utilization of electricity in a wide variety of applications was scarcely, if at all, dreamed of. Alexander Graham Bell first publicly exhibited his infant telephone at the Centennial Exhibition in Philadelphia in 1876. Charles Brush in 1878 invented the differential arc lamp, which made street lighting by arc lamps a practicable

enterprise. Edison first publicly exhibited his incandescent lamp in 1880. Sprague's mind in 1884 was planning work for himself, and such planning requires prevision, that is, soundly picturing future practicabilities. To thus foresee the future we must know facts and relationships of the past (Sprague's associations at the Crystal Palace contributed to this) and we must observe the way in which the current of history is caused to swerve by refraction as it flows from the past through the translucent present into the blackness of the future. There is always difficulty in leading the way to a new order of things; but, where willingness is great, the difficulty cannot be insuperable.

In 1887 and 1888 Sprague was providing electric cars for tramway service in St. Joseph, Missouri, and in Wilmington, Delaware; and it was in 1887 that he undertook that hazardous and spectacular contract for constructing an extensive electric railway in Richmond, Virginia, the success of which awakened all city tramway circles in the United States to the serviceability of electric traction on a grand scale in city transportation service. The Richmond road was established in continuous operation on February 3, 1888—fifty-five years ago.

The boldness of the conception and the impetuous courage of the execution which characterized the Richmond effort aroused so much interest that attention was diverted from the brilliancy of the numerous adaptations and inventions which were a part of the enterprise. But the adaptations and inventions were there, and the influence of many of them is still felt in electric traction in all parts of the world where such traction exists. Some of them had been previously embodied in experiments in a short tramway in a sugar refinery and in an equipment for elevated railway service in New York City, in which experiments regenerative electric braking of trains (an important feature in some present day heavy electric traction installations) also had been demonstrated. An old East Indian proverb says, "All oxen can carry heavy loads on a level road. Among them, the stronger ones only can carry such loads on a difficult road," and Sprague again and again proved himself to be one of the "stronger ones." For him, the willingness being great, all difficulties were overcome

I first met Sprague in 1884 at the Electrical Exhibition in Philadelphia and there was so impressed by his lively vision, enthusiasm and practical wisdom that the glamour never left me. He was eight years older than I, which is a good deal when one is under twenty years of age. But the impression did not fade—indeed, it grew more emphatic in the course of the years as I came to know him intimately as a colleague and friend. It was my privilege in 1911, as President of the American Institute of Electrical Engineers, to confer on Sprague the great Edison Medal which had been awarded to him in 1910 by that Institute, and to express the eulogy on his work which had led up to the award. Said I then in part, which I gladly say of him again:

> "The brave man carves out his own fortune, and every man is the son of his own works," says Cervantes. When Sprague invaded Richmond in 1887, resolutely plunging into a pool of difficulties from which only unceasing fertility of invention and tireless industry could extricate him, he awoke the world of transportation to an acknowledgment that the electric railway, though an infant, had a future Sprague's restless nature contrasts with the more cautious processes of the able Van Depoele, his rival in the commercial development of electric traction in America; but we forget the financial difficulties of the Richmond experiment in contemplating the brilliancy of the manoeuvre and in rejoicing in the world-wide effect of its success.

Sprague's courage and persistence became proverbial. He encountered heartbreaking difficulties but surmounted

them with success. "Trial is the true test of mortal man," and as Sprague was tested he was not found wanting. With him it seemed that whatever ought to be done can be done. Give to others in Europe and this country all due credit in the development of the electric railway as a useful agent, and we must still admit that Sprague's courageous, persistent, irresistible preaching and practice had a primary influence in bringing about the conditions and producing the inventions which came to afford modern, rapid, clean and cheap electric urban and suburban rapid transit service. So important did this development appear that Sprague's company was absorbed in 1890 by the Edison General Electric Company, which is one of the two major components which were later merged to compose the great company known as the General Electric Company.

In 1892 Sprague formed a partnership for carrying on independent inventions, but shortly thereafter he formed the Sprague Electric Elevator Company and went into the construction of electric elevators, which he delighted to look upon as vertical transportation devices —which, of course, they are. This grew into an important business before it was absorbed by other companies.

Having formulated his vision of electric elevator service, he went with dash into the business of building and installing elevators controlled by electric master-controllers such as now are commonplace where high speed elevators are needed in tall buildings. Besides introducing automatic control for elevators this led to another important invention in electric traction. Laying, in his mind, several master-controlled electric elevators in a line on the level, he invented the "multiple-unit" control for electric trains; and he introduced the invention into commercial service by means demanding a courage that commands admiration from even the deepest doubter of the business wisdom of the spectacular process. I have heard Sprague speak modestly of the multiple-unit invention as no more than a simple arrangement of devices; and, in fact it is that, but simplicity in apparatus is a natural offspring of brilliancy in conception. The multiple-unit control conferred many advantages for rapid-transit train service—among others the possibility of utilizing the weight of the total train load for traction adhesion and thereby increasing the acceleration in starting, thus increasing average speed between stops, all associated with notable flexibility in the make-up of trains

After its first application to motor-car trains on an elevated railway in Chicago, where the substitution of multiple-unit electric trains in place of steam-locomotive-drawn trains was completed in the spring of 1898 (forty-five years ago) the multiple-unit control made its impress so deeply on urban and suburban rapid transit that multiple-unit electric trains and urban rapid-transit electric transportation are substantially synonymous terms. It is of world-wide use, and it has now gone even a step farther and is used for the control of railroad locomotives with electric drive, in situations where two or more locomotive units are coupled together to get power to draw a heavy train.

It is not necessary for me to point further to the undeniable importance of the multiple-unit control. It has made rapid transit by subways in great cities a practical mode of transportation; has greatly improved the character of elevated railway and suburban train service; and has contributed to convenience in handling fast heavy trains in heavy railroad service. By these characteristics it has unobtrusively contributed to the comfort of the average dweller in the great cities. Convenience and safety are powerful forces of social cohesion. Along with this we must remember that

the production, transformation (which requires power) and distribution (which includes transportation) of animal, vegetable and mineral goods, in addition to transportation of persons, make the chain which contributes to human material welfare and comfort in living.

A great change has come over the world in twenty-five hundred years. For example, we would find it beyond comprehension that Philadelphia and New York or Boston should go into war against one another, as was characteristic of the individual cities of Classical Greece. This difference has not sprung solely from political betterment. The intimacies in the relation of culture and commerce resulting from convenient and rapid transportation, electrical communication, and the influence of productive industry make such city inter-warfare incredible to us, and wars now usually cover great areas when they occur,—areas in which the populations differ contrastingly in ideals and languages. A common language associated with the Roman alphabet is now a priceless heritage of three hundred million people of the world, including ourselves. The world needs more of such mutuality for its welfare now that great inventors have been doing such influential work in drawing nations together in their physical relations.

It seems that an engineer who creates new industries or profoundly influences old ones, needs to possess some of the same kind of courageous initiative that moved Martin Luther, Erasmus or Wesley. Something of this may be seen in the Crystal Palace tests of 1882, the Richmond electric railway work of 1887 and the conception of the multiple-unit control. It is manifest that Sprague's life was infected with the spirit of enquiry and the joy of accomplishment; and joy in useful accomplishments is essential to the realization of civilized living. Sprague cared as little for ease of body or mind, when adventure in invention was available, as a toothless man cares for a diet of nuts when porridge is available. He earned well the title often given him of "Father of Electric Traction."

"Champagne doth not a luncheon make nor caviare a meal;" and inventions of primary order usually must be fortified with many lesser but important supplementary novel features. As a consequence, Sprague's total contribution of inventions, in all types, to the electrical industries was large in number He also achieved various inventions which were of primary character but were not as important as his motor and traction contributions. Satisfaction with existing knowledge and practice is the principal deterrent to the pursuit of additional knowledge such as Sprague followed.

One of these lesser inventions produced in 1926 was the plan of two electric elevator cars in the same shaft (such as one intended for express service and one for local service) with automatic limit switches arranged to prevent collisions between the cars. Another was in the field of railroad train control, as an external automatic safety device, which strongly animated his mind when the Interstate Commerce Commission was pressing the railroads to make trial installations. However, conditions changed sufficiently so that these independent devices did not seem necessary in railroad service and Sprague's activity in the development was temporarily laid aside. Other inventions were in the field of electric signs, and he invented an alternating current, induction smelting furnace in the nineties, but the then inadequate supplies of alternating current led him to drop the project; and so on.

Sprague was not a traditional inventor without individual control over his course, like a twig in a mill race, but he

held his mind rigorously to responsibility for conceptions useful to the humankind. And his was a belief that an intense regard for the very best accomplishment available in an individual is the touchstone for maintaining (as well as establishing) a good reputation When it became necessary to relinquish steam locomotive hauling through the tunnels entering New York City for the trains of the New York Central Railroad, Sprague seized the opportunity and proposed to demonstrate hauling the trains by electric locomotives. This proposal was not accepted, but a Committee for Electrification was established under the chairmanship of W. J Wilgus who was Vice President and Chief Engineer of the railroad, with Sprague and three other men competent in railroad practices as members Plans and standards were promptly worked out, and in 1905 the project went into operation with a success that still continues, using multiple-unit operation for suburban trains and electric locomotives for drawing through trains when within the limits of the electric zone.

With all of his activity as an inventor and expounder of engineering projects, Sprague was still a good citizen who had his eye on the public welfare. In 1911, when problems arose relating to plans for additional passenger subways in New York City, Sprague became alarmed at the apparent lack of consideration for coordination of the underground transportation system for the city, and he prepared an elaborate explanation of the needs, which was presented at a special public meeting called under the authority of the American Institute of Electrical Engineers. This exposition clearly had influence on the plans which finally were adopted and put in effect.

Then with America's entry into World War I, and his nomination by the American Institute of Electrical Engineers and the Inventors' Guild to membership in the United States Naval Consulting Board, Sprague entered into its affairs with his usual enthusiasm. He was chairman of an important committee of the Board, but directed his special attention to the development of depth charges for destroying enemy submarines and the development of delayed action fuses for armor-piercing projectiles In the days of distress from the success of enemy submarines that almost isolated Great Britain from America and caused a deep food shortage in Britain, he was actuated by the doctrine that the way to strangle the submarine threat was to render the shipping lanes between the two countries so dangerous to the marauder that attacks would not be dared As a matter of fact the submarine menace was substantially eradicated by that process, and the fighting forces and the people of Great Britain, France and Belgium received the needed munitions, equipment and food.

Unless the present U-boat menace arising from the fermented consciences of Hitlerism and the Japanese is successfully met by application of the same doctrine but over a wider range of sealanes, we may come to the pass where Americans have no choice but to assume belief in what they are told to believe. We Americans may, however, rest in the expectation that present-day men of the stamp of Sprague and his confreres will be equally successful if we loyally support the utmost war efforts laid down by the military and scientific leaders.

Sprague was twice married First to Mary Keatinge of New Orleans in 1885, with whom he had one child—a son named Frank D'Esmonde (in later years known as Desmond). They made their home in New York, where Sprague's work was primarily centered. The second marriage was to Harriet C. Jones of New Hartford, Connecticut, in 1899. Here there were three children, Robert C., Julian K. and Frances A. They

gradually came to regard Sharon, Connecticut, as their home, where Sprague (as he grew older) more and more delighted in his rose garden in summer, although they maintained a residence in New York City. A creative inventor of great mental activity is said to be a man who is hard to live with in ease of spirit, and the wife who lives an unclouded life with such a one needs to possess the qualities of love and devotion in high degree. Sprague was most fortunate in his home relations.

On July 25, 1932, the seventy-fifth anniversary of his birth, a meeting was held in the Auditorium of the Engineering Societies Building in New York City at which the principal speaker was Dr. John H. Finley, who expressed an exalted view of the importance to the world's welfare of such engineers as Sprague. This reminds us that Alexander Hamilton said in the *Federalist*, "I believe it may be regarded as a position warranted by the history of mankind, that, in the usual progress of things, the necessities of a nation in every stage of its existence will be found at least equal to its resources." As progress involves the development of wants which are of a higher order, we may paraphrase Hamilton's apothegm by submitting that every nation is likely to find useful every facility and expenditure that can be secured by the utmost draft on its resources through lofty invention.

There was presented to Sprague at this anniversary meeting a tribute consisting of six beautifully bound volumes of letters and photographs from four hundred and eighty-two associates and friends, many of whom were men notable for their distinguished standing in engineering, education and art.

He was a member in many engineering societies. He received many honors and medals from societies and universities. He received the Gold Medal of the Paris Exhibition of 1889 for his development of electric railways, the Elliott Cresson Medal of the Franklin Institute in 1904 for his multiple-unit train control, the Grand Prize of the Saint Louis Exhibition in 1904 for his development of electric railways, the Franklin Medal of the Franklin Institute in 1910 for fundamental inventions and achievements in electrical engineering, the John Fritz Medal of the Founder Engineering Societies in 1934 (and conferred posthumously in 1935) for distinguished service as inventor and engineer through the application and control of electric power in transportation systems; all in addition to the distinguished Edison Medal previously referred to.

He was an honorary Doctor of Engineering of Stevens Institute of Technology, honorary Doctor of Science of Columbia University, and honorary Doctor of Laws of the University of Pennsylvania, besides being an honorary member in various engineering societies The American Institute of Electrical Engineers delighted particularly to honor him, as of it he was a past president, an Edison medalist and an honorary member. A bronze bust of him is cherished in its quarters. The Franklin Institute also delighted to honor him, as he was twice its medalist and was an honorary member. He was a past president of the American Institute of Consulting Engineers as he had been a distinguished consultant in electric railway and electric elevator matters for several manufacturers of electrical machinery and for certain railroads. Creative success is founded on faith and character, and these qualities in Sprague were fully appreciated by his associates.

He died from the effects of pneumonia on October 25, 1934, and was buried with naval honors in the National Cemetery at Arlington. On October 27, the Herald-Tribune of New York as part of a fine tribute said, "Not merely as father

of the trolley, but of all transportation by electricity, his name is firm."

An epitome of Sprague's spirit is contained in the last paragraph of a letter which he wrote to me at a date succeeding his seventy-fifth birthday celebration:

"What a lot we have seen, and what a joy it has been to have lived in, and helped make, this electric age I do not believe that any future half century will see such a widespread development affecting the march of civilization in so many diverse ways So I am glad that I have been present at the laying of the corner stone, and helped carry up some of the bricks." To this we may add that, in this age of science, the religious sense of the brotherhood of men is deeper and more favorably controlling than in any of the preceding ages of the world, and that is one of the effects of replacing the wand of the magician or medicine man by the slide rule, the blue print and the test tube If we could make, as Aristotle said long ago, the shuttle "weave and the plectrum touch the lyre without a hand to guide them, chief workmen would not want servants, nor masters slaves." It is not so much the effects of science and invention that ruin the world (as is often charged by wishful thinkers) as it is the vain culture that gets so refined that it can no longer tolerate or enjoy folk tunes like "Arkansas Traveler," "Billy in the Low Ground," "Fire in the Mountains," "Leather Britches," "Money Musk," "Pop Goes the Weasel," "Turkey in the Straw" and their relatives.

Genius is innate, a matter of birth, and presumably the consequence of some combination of the genes at conception It may or may not command world prominence, at least in its own time, but Sprague, in his single life, made engineering history and (in a fullness that few have the privilege of achieving) he added to the material comforts needed to support civilized living. As with some of the other founders of electrical engineering, it is difficult to see where Sprague secured his incentive to invention in the power applications of electricity. There was substantially no immediate heritage or environment to suggest a cause. His father was superintendent of a hat factory and his paternal forebears for generations were of conventional occupations like landowner or farmer Of maternal ancestors we know little Sprague's own mother apparently was devoted to her children, but she died while Sprague was young and he fell under the care and direction of a maiden, school-teacher aunt, who apparently was rather reserved. As the spirit for adventure in invention was apparently in Sprague before he went to the Naval Academy, it seems to have been an inheritance since there appears insufficient cause in his youthful environment to originate such a spirit. We are thus left without clues as from whence came the genes which in combination produced his genius, but we know that he lived with an urge to make inventions that would be useful to the human kind.

"One star differeth from another star in glory" the Apostle said, referring to tangible appearance. We use his words, but apply them to imponderable human characteristics of the individuals. Frank Julian Sprague was a star of magnitude. If all the world would permanently embrace peace and live with industry and thrift, while encouraging creative inventors to show the way to convenience and comfort, we soon would enjoy a wealth, health and happiness near to the millennium

HISTORY OF THE MEASUREMENT OF HEAT

I. THERMOMETRY AND CALORIMETRY

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THE years 1942 and 1943 mark important anniversaries in the history of thermal quantitative methodology. They celebrate the 350th year since the invention of the thermometer (c. 1592) and the 200th year of the scale of Celsius (1742). They commemorate the death of the inventor (Galileo, † 1642), and the birth and death of two who improved the instrument (Newton, b. 1642 O S, 1643 N.S ; Halley, † 1742). These years also mark precisely a century since Mayer (1842), Joule (1843), and Colding (1843) established the principle of the conservation of energy, the greatest generalization which thermometry has made possible The present time may therefore be regarded as peculiarly fitting for a review of the basic steps in the development of quantitative thermotics.

The importance of thermal phenomena had been remarked as early as the Hellenic period. Heat and cold were recognized by Democritus and Heraclitus as playing a vital part in the dynamic world of nature, and these qualities were intimately bound up with the Empedoclean theory of the four elements and with the Hippocratean humoral pathology. The classical expression given to such doctrines about a century later by Aristotle and his school continued to dominate scientific thought for close to two thousand years. Peripatetic science, however, remained essentially *qualitative* and failed to see the possibility of, or at least the tremendous importance of, a means of determining the extent to which the properties hot and cold were present in any given situation.

Hellenistic science stands in marked contrast, in its attention to *quantitative* studies in astronomy and mechanics, both to the earlier Hellenic period and to the later Greco-Roman age. However, no basis for the measurement of thermal phenomena was found at that time. Heat could not be seen or weighed, and the physiological sensation was far too unreliable to serve as a measure. It is scarcely surprising, then, that the determination of specific heats came about two thousand years after the earliest measurements of specific gravity, and that the inverse proportionality of these for gases was discovered another hundred years later. Nevertheless, a bold attempt in the direction of a quantitative study of heat was made in medicine by Galen through a classification of drugs and simples on the basis of a scale of four orders or degrees of heat and cold. Such an arrangement was bound to be highly subjective and dogmatically a priori, but it served to inspire further efforts toward a quantitative basis. In particular, the Galenic views were continued and elaborated upon by Arabic commentators, so that in the work of Alkindi (c 850) one finds adumbrations of an important distinction—that between intensity and quantity of heat and cold.

The decline of Arabic learning happily coincided, at least roughly, with the rise of a more vigorous scientific interest in the Latin world. The natural science of Aristotle was eagerly discussed by the Scholastic philosophers and, especially at Paris and Oxford during the four-

teenth century, by them was given a significantly new quantitative orientation. This tendency was most pronounced in two fields upon which the mathematical mind of Archimedes had failed to touch—dynamics and thermotics. In the former branch the late medieval period introduced two important concepts—that of impetus or inertia and that of acceleration, both uniform and non-uniform. That the age was somewhat less successful with respect to the study of heat may perhaps have been due to the fact that it studied the dynamic aspects of heat without first having mastered thermostatics. Richard Suiseth and others discussed changes in thermal intensity and content in much the same terms as they had linear velocities and accelerations; and Nicole Oresme represented such variables graphically. During the fifteenth and sixteenth centuries these discussions were continued. Giovanni Marliani and his contemporaries and successors adopted a scale of eight degrees of calidity and frigidity, and on this basis sought to distinguish between the temperature of an object and the quantity of heat which it contained. However, speculation and logical deduction here remained relatively fruitless because no sound body of raw data had yet been gathered through precise quantitative observation. It is interesting to note in this connection that although during the medieval period it was suggested that heat might be a form of motion, anticipating Francis Bacon and others by some three hundred years, such an adumbration of the modern view could not take on appropriate significance without the empirical mensurational work which during the seventeenth and eighteenth centuries followed upon the invention of the thermometer.

The earliest forms of the thermometer appear to have been suggested by the sixteenth-century revival of interest in the classical mechanical works of antiquity, rather than through Scholastic philosophical discussion The technological tendencies of the Greek world had been overshadowed to a great extent by the speculative tradition which medieval thought had sedulously fostered. Consequently the works of Archytas of Tarentum, of Philo of Byzantium, of Ctesibus and Hero of Alexandria survive now only in the form of fragments preserved largely through Latin translations of Arabic versions of the Greek originals And yet the mechanical experiments of these men played a significant role in directing the advance of early modern science, especially with respect to thermal measurement.

In a *Treatise on Pneumatics* of the third century B C Philo described an intriguing experiment which was destined to have far-reaching implications. A large hollow glass globe was sealed hermetically to one end of a long glass tube, the other end of which dipped into an open flask filled with water Philo found that when the apparatus was placed in the sun, some of the air within the globe was forced out through the water in the flask On being placed in the shade, water flowed from the flask back along the glass tube and even into the sphere of air. This simple demonstration of the expansive property of air was repeated with numerous ingenious modifications by Hero, who cites Philo in this connection

Although Philo's discovery became the basis of various clever automatic devices, it appears never in antiquity to have been tied up with philosophical discussions on the qualities hot and cold. This apparatus of some twenty-two hundred years ago is in all essentials a thermoscope, but such an appropriate interpretation apparently occurred to no one in ancient or medieval times.

During the later sixteenth and early seventeenth centuries Hero's works became well-known Della Porta was in-

terested in Hero's *Pneumatica* chiefly as furnishing examples of "natural magic." Consequently in 1589 he described the experiments of Philo and Hero as illustrating the changing density of air; the idea of this as a measure of the degree of heat did not occur to him. To Galileo, however, such an interpretation did occur soon after he was established at Padua in 1592, just about three hundred and fifty years ago Using Philo's arrangement, Galileo fastened a straight thin glass tube to a hollow glass ball about the size of a hen's egg This he then held vertically with the open end of the tube in a flask of water. As the glass ball was warmed by the hand, air was driven out of the tube and bubbled up through the water. When the hand was removed, water rose in the tube as the enclosed air cooled and contracted. The level to which the water rose in the tube Galileo recognized as a rough indication of the extent to which the air had been heated. Galileo was thus the first one to give a means of determining temperatures independently of the highly equivocal sensation of touch. His device is to be regarded as the earliest crude thermometer, the first objective means of describing thermal phenomena quantitatively. However, inasmuch as in this early form it lacked a definite scale and was subject to changes in atmospheric pressure, Galileo's instrument frequently is referred to as a baro-thermoscope.

Galileo seems not to have appreciated his invention of the thermometer, his reference to it being quite casual. Consequently credit has sometimes gone to rival claimants, although it appears to be clear from Galileo's correspondence that he is definitely entitled to priority in this invention, the description of which has been supplied by his associates. During the eighteenth century the invention customarily was ascribed to Drebbel in 1608; but Drebbel's position was precisely that of Porta—he repeated the observations of Philo and Hero, but seems not at first to have used the instrument as a heat-measurer. Serious pretensions have been advanced also on behalf of the Paduan physician, Sanctorius, who in about 1612 described thermometers in connection with commentaries on the works of Galen and Avicenna. Sanctorius, however, never claimed the invention for himself, and it is possible that he learned of the instrument through his colleague Galileo Independent invention has sometimes been ascribed also to Salomon de Caus in 1615, to Fra Paolo Sarpi in 1617, or to Robert Fludd even later, but such ascriptions lack adequate confirmation.*

Whereas the use of the telescope spread rapidly after its invention in 1608, application of the thermometer was by contrast surprisingly slow. This situation is probably to be explained by the fact that the former instrument was applied in *qualitative* description, whereas the latter was intended for *quantitative* determinations. Quantitative analysis is more difficult than qualitative, although it is also generally more valuable. To make the thermometer an effective measure of heat intensity a precise and objectively reproducible scale was necessary; but throughout the seventeenth

* While this paper was in proof, there appeared a valuable review of the claims of Galileo, Sanctorius, Fludd, and Drebbel by Dr. F. Sherwood Taylor in "The origin of the thermometer," *Annals of Science*, V (1942), 129–156. Sherwood closes his excellent analysis with the following paragraph:

"To sum up the whole position, it seems not improbable that Santorio, Galileo, Fludd and Drebbel each invented the thermometer independently. Galileo seems, at some period between 1592 and 1603, to have been the first inventor, while Santorio in 1611 gives the first written record of the invention, published or unpublished. Drebbel may have invented the two-bulbed thermometer at any date between 1598 and 1622. Fludd may have modified Philo's apparatus into the weather-glass, but did not do so until some period between 1617 and 1626."

century no such standard was adopted. Many of the early scales—including those of Telioux in 1611, of Mersenne in 1644, of Morin in 1661, and of Fabri in 1669—were divided into eight spaces, following the late medieval philosophical tradition. Sometimes these intervals were further subdivided into eight or sixty parts each—the latter in accordance with the Babylonian astronomical tradition. Astronomy and geometry undoubtedly led Galileo's friend Sagredo in 1615 to divide the interval between the greatest heat of summer and the extreme cold of winter into 360 parts or "degrees." The famous thermometers of the Florentine Accademia del Cimento were variously divided into fifty or one or more hundred parts. Otto von Guericke adopted a scale of seven degrees and Fludd one of fourteen Renaldini and Newton used scales of twelve parts.

As there was no uniformity during the seventeenth century with respect to scale divisions, so also no general agreement was reached as to desirable fixed points for determining the limits of the scale. Winter and summer heat, the temperature of a deep cellar, the melting point of butter or of anise-seed oil, the freezing and boiling points of water were among those proposed; but not one of these secured general approval.

During the century the form of the thermometer had changed considerably. Jean Rey in 1632 described a thermometer for fever patients in which a rise of temperature was indicated by the expansion of water in a flask up into a long thin neck. This liquid thermometer was followed by others, including the alcohol and mercury instruments of the Florentine Academy. The change from air to a liquid as the thermometric substance reduced the discrepancies due to atmospheric pressure, but did not wholly eliminate them. At some time before 1654, however, Ferdinand II and the Academicians sealed their thermometers and removed this source of error. Greater accuracy was now attainable, provided some standard method of calibration could be adopted. Boyle, Hooke, and Huygens in 1665 suggested that a *single* fixed point, such as the freezing or boiling point of water, be chosen as a starting point, and that temperatures above and below this be measured by the proportionate expansions and contractions of the thermometric substance. Adoption of this principle would have made thermometers universally comparable, but agreement could not at that time be reached. Shortly afterwards it was suggested by Fabri, Dalencé, Renaldini, Newton, Halley, Roemer, and others that *two* fixed points would be preferable, the interval between these to be subdivided in some manner to be agreed upon On the basis of these principles,—using either one fixed point or two—the thermometric scales which we now use—Fahrenheit, Centigrade (or Celsius), Réaumur, and Absolute—were established during the first half of the eighteenth century

The origin of the Fahrenheit scale is to be found in the work of Roemer. The Danish astronomer in calibrating thermometers set his zero at the lowest temperature he could obtain with a mixture of ice and salt; his upper point was the boiling point of water. On dividing the interval between these extremes into sixty parts, Roemer found that the freezing point of water fell at about 7½ or 8 and the temperature of the body at 22½. Fahrenheit in 1708 visited Roemer in Copenhagen and subsequently undertook the calibration of thermometers along similar lines. As a maker of meteorological instruments—the thermometer was indeed at that time often referred to as a "weather-glass"—Fahrenheit was concerned primarily with the lower portion of Roemer's scale. He therefore retained Roemer's zero, but as his upper fixed

point he adopted normal body temperature. Moreover, he found Roemer's 22½ divisions between these points inadequate for precision, so that he multiplied the number by four Subsequently he found it convenient to change from 90 to 96 the number of degrees in this range With these modifications, as the result of which the freezing and boiling points of water incidentally fell at 32 and 212 respectively, the present Fahrenheit scale was established.

The origin of the Centigrade thermometer is not so clearly indicated. A scale of a hundred parts had appeared among those adopted by the Florentine Academy, and other centesimal thermometers were used in the first half of the eighteenth century by La Hire and Du Crest, but these were not associated with both the freezing and boiling points of water On the other hand, Renaldini in 1694 had proposed these latter fixed points, but he subdivided the interval duodecimally. A suggestion that Renaldini's fiducial points be associated with a centesimal scale is contained in a letter of the great naturalist Linnaeus, but this is undated and so leaves unanswered the question of priority. Apparently the first thermometer constructed along those lines was that described in 1742 by Celsius. In this the freezing point was chosen as 100 and the boiling point as 0, but a few years later the scale was inverted by his colleagues to establish the present Centigrade scale.

In the period between the work of Fahrenheit and that of Celsius there arose a third scale which also achieved wide popularity. In 1730–1731 Réaumur proposed a thermometer established on the principle of Boyle, Hooke, and Huygens. Starting from only one fixed point, the freezing point of water, he chose his divisions on the basis of the volumetric expansion of the thermometric substance —one degree for each increase by 1/1000 of the original volume of alcohol. On this scale water was found to boil at 80°. However, because of the varying quality of thermometric spirits, this boiling point subsequently was adopted as an arbitrary and invariable second fixed point, thus standardizing the scale for so-called Réaumur thermometers

Interest on the part of both Fahrenheit and Réaumur had been influenced by the earlier works of Amontons, to whom is due the idea of an absolute scale of temperature Amontons had been led to thermometry through meteorology and the problem of varying atmospheric pressure, but in emphasis he departed from the traditional view. The air thermometer had been the first to be developed, but it had soon given way to sealed liquid thermometers. Liquids, unfortunately, have not only very small rates of thermal expansion, but these rates are unequal for different substances and are not uniform for any one fluid over different temperature ranges The same is true also of solids, the unequal expansions of which were used in 1747 by Musschenbrock to construct a new type of thermometer or pyrometer About 1701, on the other hand, Amontons had discovered that the thermal expansion of air is surprisingly uniform. He found that if a fixed volume of air at any initial pressure is heated from a moderate temperature to the boiling point of water, the pressure will in every case be increased by about one third. From this fact he inferred that for equal increments or decrements in heat or temperature the pressure of a gas will be increased or decreased by the same fraction of the pressure at some arbitrary point. He therefore suggested a scale based on one fixed point—the boiling point of water—with degrees of heat intensity to be measured in terms of the proportionate increase or decrease in the pressure of a given volume of air at this initial temperature. Thus Amontons found that a pressure of 73 units at the boiling point corre-

sponded to one of 58 units at greatest summer heat and to one between 51 and 52 units at the freezing point. He then made the significant observation that by extrapolation below this point one could infer that at the zero temperature of this scale the air would exert no pressure; it would have no elasticity because its parts would then be contiguous and cease to move. He suggested that this might well be regarded as an absolute zero of heat content or intensity However, scientists at the time were skeptical of his conclusions, and this suggestion of an absolute thermometric scale remained largely unnoticed. Late in the century and early in the next Amontons' observation on air was rediscovered and generalized for other gases by Lambert (1779), Charles (1787), Volta (1793), Gay Lussac (1801), and Dalton (1802) Toward the middle of the nineteenth century this work on gases was associated by Kelvin and Clausius with independent developments in thermodynamics which also pointed to the same absolute zero, and hence temperatures measured from this point (by means of the adjusted Centigrade system) often are referred to as degrees Kelvin or Absolute

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The establishment in the early eighteenth century of adequate thermometric scales gave precision to the idea of heat *intensity*. The problem of heat *quantity*, on the other hand, had received no satisfactory consideration The recognition of the constancy of fixed points, on which thermometry is based, preceded by about a century the determination of heat capacities upon which calorimetry depends. Arabic and Scholastic philosophers were aware that thermal effects are determined by both intensity and quantity of heat and cold. The latter factor, they knew, was to some extent dependent upon the quantity or mass of the hot and cold bodies. They accepted this functional relationship as a simple proportionality. Renaldini, Fahrenheit, Boerhaave, and others did indeed establish experimentally that, when unequal quantities of the *same* substance at different temperatures are mixed, the rise or fall in temperature is very nearly proportional to the masses involved and to the difference in temperature. In the case of two *unlike* substances, however, this rule failed to hold. Mercury, for example, had far less thermal effect at a given temperature than did an equal mass of water. In fact Fahrenheit, following a suggestion of Boerhaave, had found on mixing equal *volumes* of these two substances at different temperatures that, although the density of mercury was more than thirteen times that of water, the thermal effect of water was in every case greater by about three to two This experiment might well have led these men to make a systematic quantitative study of the heat capacities of various substances. On the contrary, Boerhaave looked upon the result as confirming roughly his conjecture that heat tends to be distributed uniformly throughout all space, regardless of the substance occupying any portion of this space He held that observed discrepancies in thermal density or capacity were due to inaccuracies resulting from the fact that heat quits and is acquired by bodies at varying rates In fact, attention at the time seems to have been drawn away from the idea of heat capacity by a strong interest in speeds of thermal communication, such as Newton's law of cooling. Richmann in 1753 noticed that mercury gives up its heat very rapidly, and that substances in general have characteristically different rates of cooling; but he failed to distinguish clearly between temperature and thermal capacity.

The view of Boerhaave precluded any such concept as that of specific heat, but it pointed toward the possibility of a direct measurement of the amount of heat in a given region of space. The idea

of materiality had been impressed with such thoroughness on the eighteenth century that Boerhaave was led to attempt to weigh heat, for gravity is one of the chief properties of matter. Moreover, the fact that metals increase in weight during calcination tended to confirm the suspicion that heat was a gravitating substance. The results of Boerhaave's experiments, however, were distinctly negative, and he was forced to conclude that heat was a material *sui generis* having no weight. Musschenbroek and Buffon questioned this conclusion, and the latter insisted that he could indeed associate an increase in weight with a rise in temperature. However, Black, Rumford, and others were not convinced by Buffon's results, and heat remained throughout the century among the imponderables.

The *absolute* quantity of heat could not be determined by the balance, but successful attacks upon the problem of *relative* quantities of heat were nevertheless made independently by a number of men, with credit for priority apparently going to Black. He arrived at his results shortly before 1760, although they were not published during his lifetime. The result of Fahrenheit and Boerhaave on mixing water and mercury impressed Black as having a significance which, surprisingly, these men had overlooked. Rather than indicating roughly the uniform distribution of heat in space, Black saw that the experiment showed clearly that different substances have characteristically different capacities for heat. The capacity of mercury, for example, he found to be less by about 30% than that of an equal volume of water. Experimental determination of the capacities of substances relative to that of water were made also at somewhat the same time by Deluc, Wilcke, Irvine, Crawford, Lambert, Watt, and others. Such values, when equal masses are compared, have since become known as specific heats. This work inaugurated what may be regarded as a second great branch of quantitative thermotics. It is a surprising fact that thermometry, or the determination of heat intensities, had developed for more than a century and a half before the effective rise of calorimetry, or the measurement of relative thermal content or capacity. This is difficult to explain inasmuch as no new instrument was necessary in the latter case. A balance and a thermometer suffice to measure the relative heating effects. The method of mixtures long before had been used by Renaldini in connection with quantities of a single substance at different temperatures to determine the degrees on a thermometric scale. Calorimetry would follow as a simple corollary on mixing quantities of two different substances at unequal temperatures. Yet this was not systematically developed until it had been bound up by Black and others with the interesting phenomena of change of state and the discovery of latent heats.

Experience had shown that the temperatures at which substances undergo a change of state are more or less fixed and constant. On the other hand it was apparent that a given quantity of a substance did not freeze or boil away instantaneously on being lowered or raised to or beyond the freezing or boiling point. The very appreciable lag in this connection was interpreted as due to the fact that air, through which the transfer of heat is generally made, is almost 800 times less dense than water and hence absorbs or gives up very slowly the heat necessary for equalization of temperature. No appreciable increase in the total heat content of a body was judged necessary to melt ice or to boil water, so long as the temperature was maintained at or above the freezing or boiling point. Such serious misconceptions show that satisfactory quantitative studies often are of greater significance in the advance of

science than are general theories as to the nature of things. Such at least was true of the science of heat in Black's day.

Black in 1757 had found reason to question the traditional view with respect to change of state. He saw that if no great change in heat content were necessary to bring about a change of state, then it would be truly remarkable that ice melts so slowly in warm surroundings. Great quantities of snow and ice on thawing should rather be expected, through sudden liquefaction, to produce irresistible torrents and inundations. Black concluded that, contemporary opinion notwithstanding, a great *increase in the quantity* of heat must be brought about to give melting ice its fluidity, even though this is not accompanied by any *rise in temperature*. The added heat was merely "rendered latent." Moreover, for any one substance and change of state, this latent heat was a perfectly definite quantity directly proportional to the mass involved. In view of this, Black thought of the melting process as a sort of chemical reaction: a mass of ice at 32° when combined with 139 degrees [Fahrenheit] of heat yields an equal mass of water at this same temperature. His figure for the latent heat of fusion thus differed but slightly from the modern value. For the latent heat of vaporization, however, Black arrived at "not less than 774 degrees [Fahrenheit]," which is smaller by almost 20 per cent than that accepted at the present time.

Black utilized his discovery and determination of latent heats as an alternative method of determining relative quantities of heat or of thermal capacities. If a hot body is placed in a cavity in a block of ice which is then covered with a slab of ice, the quantity of heat lost by the body in cooling to the freezing point of water will be directly proportional to the mass of ice which is melted. So convenient was this method of determining heat quantities, when used in connection with improved ice calorimeters, that the amount of heat required to melt a unit weight of ice in many cases was taken as the unit of heat, replaced now by the calorie and British thermal unit.

The calorimetric researches carried out by Black and others fortunately were not subject to qualifications which might follow from a particular theory as to the nature of heat. This work answered only the question "How much," not "How" or "Why" in some mechanistic sense which might "explain" the phenomena of heat by appealing to analogies with other more immediate and familiar experiences. Black himself was never a lover of theory and so seems to have felt a definite reluctance to adopt any specific doctrine in this respect. By that time the Aristotelian view of heat and cold as primary and unanalyzable qualities had been abandoned. In the seventeenth century Bacon, Descartes, Boyle, Hooke, Huygens, Hobbes, Locke, and Newton had reiterated the medieval suggestion that the essence of heat was in some way to be found in motion. In spite of the rapid rise of dynamics, such a doctrine at the time remained sterile because the relationship between heat and the ordinary phenomena of motion could not be expressed in quantitative form. Atomists, such as Gassendi, rejected the dynamic theory and advanced instead the view that heat was not a quality but a substance, a subtle fluid the particles of which insinuated themselves into the interstices of matter. Cold was by some likewise regarded as a substance, until in 1790 Prevost's theory of exchanges replaced the doctrine of frigorific rays. Boerhaave, Musschenbroek, and Buffon meanwhile had sought in vain to establish the material view of heat quantitatively through the balance, but their failure did not alter the relative plausibilities of the substantial or

materialistic and the dynamic or mechanical theories of heat. Adherents of the former had the ready answer, suggested by optical, gravitational, magnetic, and electrical phenomena, that heat was an imponderable substance. Moreover, Newtonian influence favored a view which could be expressed in terms of attractive and repulsive forces between particles. Boerhaave's fluid theory therefore dominated thought for over a century. When in 1738 the Académie des Sciences offered a prize for an essay on the nature of heat, the three winners (Euler, Voltaire, and the Marquise du Châtelet) all postulated the substantial theory. This view of heat adequately satisfied the craving for an interpretation which could be visualized in terms of sensory experience. Moreover, it was flexible enough to allow of modifications *ad hoc* to explain such phenomena as elasticity, change of state, modes of communication, thermal expansion, heat capacity, heat of compression, latent heat, and solar radiation It was generally assumed that the caloric particles were in constant motion, that they repelled each other, and that they were attracted to the atoms of a substance with a force which varied with the heat capacity of the material During compression, or on rubbing substances, some of the caloric of the body was squeezed out, thus causing the body to become sensibly hot. Conversely, the intrusion of more heat into a body resulted in a greater internal repulsion among the caloric particles and hence resulted in an expansion of the substance. A change of state could be brought about by injecting heat in such amount that the attractive bonds of the atoms of the substance were overcome by the repulsive forces of the caloric particles for each other. The additional heat necessary to overcome these atomic forces was not free but was in some way bound up with the substance; *i.e*, it was latent and produced no sensible increase in the temperature of the substance. The idea that heat was material was rendered plausible also by the confusion between ordinary sensible heat and radiant energy. Solar radiation was regarded simply as a steady stream of caloric particles, a view which in its simplicity contrasted markedly with the need on the part of dynamic theories of heat and light for a supposititious all-pervading medium or ether possessing quite extraordinary properties. In view of such a ready adaptability to all situations, it is small wonder that the substantial doctrine of heat persisted up to the middle of the nineteenth century Fortunately, however, quantitative experimental work in thermotics meanwhile was hampered little, if at all, by notions as to the ultimate nature of heat. Indeed, a certain indifference toward such speculations was evinced not only by Black but also by Laplace and Lavoisier who continued his calorimetric researches.

In the *Mémoires* of the Académie des Sciences for 1780 Laplace and Lavoisier published a paper on heat which contained points of view of great significance. During a review of the respective advantages of the dynamic and materialistic theories of heat, the authors pointed out that in either case the conservation of free heat in the mixing of bodies was admitted by physicists. This paralleled the conservation of mass which Black and Lavoisier had demonstrated in chemical reactions. Then Laplace and Lavoisier indicated that if heat were motion, it should be measurable in terms of $[1/2]mv^2$, or kinetic energy. This observation might have stimulated investigations leading directly to the laws of thermodynamics. Unfortunately the authors of the article seem to have been unaware of the possibilities lying in this direction, for they dropped the idea and went on to a consideration of heat as a material substance. The thermal fluid

was enthroned among the chemical elements as Lavoisier's "caloric," and many years later Laplace in his *Mécanique céleste* continued to support the material theory.

Laplace and Lavoisier failed to forge the quantitative link between heat and motion, but they did make significant contributions in the quantitative correlation of the chemical and biological aspects of thermal phenomena The phlogiston theory had made thermal phenomena so completely a part of chemistry that the latter subject was known as the science of heat and mixture. Lavoisier was directly responsible for the overthrow of phlogiston through the substitution of the oxygen theory of combustion and respiration, but he retained a "chemical" view of heat. This view may, incidentally, account for the myopia with respect to a quantified mechanical theory. The caloric doctrine appealed more strongly to men who were keenly aware of the need for quantitative statements It was natural, then, that an attempt should be made to measure the amount of caloric which is evolved during the chemical process of combustion Laplace and Lavoisier burned charcoal in their improved ice calorimeter and determined that in this oxidation the production of one ounce of fixed air (carbon dioxide) from food and pure air (oxygen) was accompanied by heat sufficient to melt 26 692 ounces of ice. Inasmuch as there was at the time no concept of energy or, *a fortiori*, of chemical energy, Lavoisier believed that during combustion some of the heat which had been combined with the oxygen principle in the pure air was liberated as sensible heat

Ever since the days of classical Greek medicine the lungs had been regarded as playing a thermostatic role in tempering the vital heat of the blood. However, Lavoisier held that the function of respiration is to supply to the lungs the newly discovered element oxygen which there combines chemically with the products of digestion to maintain the heat of the body. To show that this oxidation is entirely comparable to the ordinary visible process of combustion, Laplace and Lavoisier sought to determine calorimetrically the quantity of heat generated in animals during the formation of carbon dioxide Because their method failed to take into account the oxidation of hydrogen, the result was too high—about 13 7 ounces of ice for 224 grains of fixed air—but it was sufficiently close to the expected result to indicate that respiration is a combustion during which the heat lost by the body is renewed through the conversion of oxygen to carbon dioxide Animal heat was shown to be not perceptibly different from caloric. This was a vindication of that faith in the unity of nature which had been expressed boldly by Buffon and which later inspired the discovery of the conservation of energy Moreover, it made possible for the first time an understanding of that color contrast between arterial and venous blood which sixty years later directed Mayer to this very law which Laplace and Lavoisier so narrowly missed.

The collaboration of Lavoisier and Laplace on the specific heats of gases had failed to yield satisfactory results, yet such efforts also led directly toward Mayer's work The basic law of *thermometry* for air (and for other gases) had been established by Amontons at the beginning of the eighteenth century, but the *calorimetry* of gases was undeveloped a hundred years later The elasticity and low specific gravities of gases delayed the determination of their specific heats long after they were isolated and identified French scientists of the first half of the nineteenth century devoted much attention to this problem before arriving at a satisfactory solution. After Gay-Lussac in 1802 had rediscov-

ered and generalized the law of Amontons, he turned his attention to the thermal capacities of gases. Ten years later he still lacked accurate values for their specific heats, but he had made the important discovery that the heat capacities of equal volumes of air, hydrogen, oxygen, and nitrogen were nearly equal. The following year Delaroche and Bérard verified this fact through the first reasonably accurate direct measurement of the specific heats of gases at constant pressure. The determination of specific heats at constant volume nevertheless still presented difficulties. In 1816 interest and attention to this problem were heightened by a bold conjecture on the part of Laplace. For well over a century no one had been able to explain why the velocity of sound as *calculated* by Newton from the elasticity of the air should be smaller by about 1/6 than the *observed* speed. Laplace finally hit upon the correct explanation: the vibrations constituting sound waves are so rapid that the compressions and rarefactions are not isothermal, as Newton had supposed, but adiabatic. On the basis of such vibrations Laplace was able to show that Newton's calculated velocity of 997 feet per second is corrected on multiplying it by $\sqrt{\gamma}$, where γ is the ratio of the specific heat of air at constant volume to the specific heat at constant pressure. Laplace estimated γ as 3/2, but the known velocity of sound showed that γ should be about 1.4. This latter figure was confirmed somewhat later by the values of γ and of the specific heats of diatomic gases obtained by Clément and Désormes, Gay-Lussac, Dulong, Regnault, and others. Such data, through the kinetic theory of gases, confirmed the discovery of Dulong and Petit in 1819 that heat capacities are directly associated with atomic theory. Moreover, during the second quarter of the century this work was destined, through the establishment of the law of the conservation of energy, to play a central role in the rise of the theory of thermodynamics, which was the third stage in the development of quantitative thermotics.

MALARIA: MALADY OF THE MARSHES

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SUPERSTITIONS as to the origin of a disease often serve to indicate the frequency of its occurrence For where one's speculation is, there one's concern is also. Consider the case of malaria. Still among man's serious ills, it has given rise to a wide array of highly fanciful views.

It has been thought, for instance, that febrific poisons arising from fissures in the earth's surfaces were responsible for the malady. There was the belief, too, that milk exposed to the night air would entangle epidemic swamp poisons—that gases from decaying vegetation, or ethereal oils from living plants, might produce the disease. Some people were even reluctant to gather swamp grapes, because the exuded juice might trap the "noxious effluvia" of the marshes. Even the heavenly bodies came in for a share of suspicion. The sailor viewed with special alarm an eclipse, or a moon that was full. Tides, climates, and seasons also, were blamed at times for febrile epidemics otherwise unexplainable.

But, if there have been new additions to the catalog of popular theories in

even fairly recent times, accounts of malaria itself date back to the earliest days of recorded medicine In Biblical times mosquitoes infested the valley of the River Jordan and the Dead Sea, consequently some of the fever illnesses referred to by the scriptural writers very likely are malarial. There is the account, for example, in Leviticus 26.16 in which the author speaks of "the burning ague." In Deuteronomy 28:22 the writer mentions fever and "an extreme burning." Still another passage, Matthew 8:14, records Jesus' visit to Peter's home where his wife's mother lay sick with fever. Further, a reference in Luke 4:38 relates that the mother of Simon's wife fell ill with "a great fever " Fever is again mentioned in John 4:52, and in Acts 28:8 Publius' father is described as suffering from both fever and dysentery. These ancient accounts do not, of course, constitute in themselves an accurate basis for a diagnosis of malaria However, there is the further consideration that early Palestine was so situated as to make the presence of malarial epidemics highly probable

In the days of ancient Greece the population of Athens and the surrounding country experienced repeatedly the calamitous consequences of malaria. Mosquito breeding grounds were abundant in the numerous swamps about Athens, and the site of the famous stadium was once a marsh. The unhappy effect of such conditions upon the inhabitants was vividly represented in Aristophanes' reference to the "shivers and fevers which by night strangled your fathers." Similarly, the physician Protagoras speaks of intermittent fevers terminating fatally—probably the pernicious variety of malaria. It is known, too, that there was speculation as to the role marshlands played in producing fevers, and that the Italian Varro (B.C. 116–27?) suspected that inhalation of swamp organisms caused disease. Opinions like these were held in other localities as well, since excavations have revealed that drainage was practiced in Greece, Crete, and elsewhere. Records indicate that Rome was believed more healthful than the rest of the Italian peninsula because of its elevation, and since its valleys were drained by the Cloaca Maxima Even so, fevers were prevalent enough for Cicero (B.C. 106–43), and later Livy (B.C. 59–A D. 17), to select "pestilencia" as descriptive of conditions in the outlying districts of the imperial city Finally, malaria swept over both countries with uncontrolled violence, very probably contributing to the decline of Grecian culture, and to the subsequent fall of the Roman empire

As to just what sufferings were visited upon the peoples of the Old World, we have no exact way of knowing. However, accounts do suggest that both benign and malignant malaria continued to reign with murderous fury. Then, by the time of the seventh century, we are again provided with specific evidence as to the prevalence of the disease for Bede, in England, refers to malaria in his *Historia Eccleciastica Gentis Anglorum.* Not long afterward, during the ninth century, we find the Persian Rhazes, who was credited with being the first eminent physician to write in Arabian, asserting that the spleens of those who drank marsh water became enlarged and hard Somewhat later, Avicenna, writing around 1000 A.D, clearly revealed a familiarity with quartan fevers. It is interesting to note, too, the recognition which this Mohammedan philosopher accorded to the therapeutic possibilities of benign malaria, for in his Canon of Medicine he states: "One disease becomes the medicament for curing another."

As to whether, during all this time, malaria was prevalent in the western world we must depend upon conjecture

—though the impression is that it was widespread among the Indians of South America, especially the Incas of Peru. We do know, however, with the coming of the era of exploration, that malarial-like fevers materially interfered with the colonizing enterprises of the European adventurer. There is the account, in this respect, that Columbus was seized with "terrible fevers" in January, 1494, while in Hispaniola. Also, malaria was prevalent in that country following the introduction of Negro slaves in 1501. In contrast, the early Spanish settlement in Florida in 1566 was less affected than were the English colonists who later attempted to settle Jamestown It was from this time on, however, that malarial fevers assumed an increasingly important role in New World history.

Meanwhile, back in the Old World men were still endeavoring to understand the true nature of an old problem along with their interest in a New World Epidemics like that of 1557–58 in England wrought deadly havoc and wrecked many enterprises. Yet, such tragic ravages in England, as well as those on the Continent, stimulated a more thorough study of fevers Such was the contribution in 1624 of the Belgian physician Spigelius. His four books on *Semitertiania* provided a lengthy treatise on intermittent fevers, and a good description of the paroxysms. Later, in 1692, the celebrated London practitioner, Richard Morton, made his distinguished contribution entitled *Pyretology*. Then Francis Torti, a Modena professor, in 1712 published a classical work on pernicious fevers, and other contributions were to follow, lending further inspiration to the relatively new spirit of research.

Although at this late date in the history of the disease advances were being recorded as to the nature of fevers, creditable efforts had been made very much earlier. Even as far back as 500 B.C. Hippocrates, moved by the "shivers and fevers" of his countrymen, had endeavored to discover more exactly the nature of their ailments. As a result of his study of fevers he felt they should be classified as "the continual, some of which hold during the night and have a remission during the day; semi-tertians, tertians, quartans, quintans, septans, and nonans." Of these types he considered the quartans least dangerous, and he contended that they "carried off other great diseases." Some time later, around 180 B C, Plautius, too, wrote of fevers, as did Celsus in 50 A.D. Then a century passed, and Galen ventured the opinion that all the quotidian fevers resulted from phlegm, that yellow bile induced the tertian, and black bile, the quartan attacks Quartan fevers, he concluded, were effective in "carrying off" attacks of epilepsy.

Although this knowledge of fevers resulted from studies made over many centuries, contributions as to treatment were more immediately productive once cinchona had been discovered. Some of our earliest information goes back to about 1620 when a Jesuit missionary at Chucuifaca, Peru, learned from the natives that a miraculous bark could heal those suffering from malarial fevers. Later accounts romantically tell of the Countess, wife of the viceroy of Peru, falling ill in 1638 with a fever from which her physician, Juan de Vega, could not deliver her. A Spaniard, possibly the governor of Loxa, advised her physician to use the bark of the tree which contained the secret febrifuge. At first hesitant, she finally resolved to follow his advice and recovered "as if by enchantment." A year later she and her physician sent some of the powdered bark to Spain. Ten years afterwards the Jesuits of Rome introduced it commercially in Italy as "Jesuit's or Cardinal's Powder," and in Spain as "Countess' Powder." In 1677 the cinchona bark

appeared in the London Pharmacopoeia as "Crown Bark," and the red bark was included ten years later. We know that cinchona at first was a costly article, and that de Vega sold it in Italy for nearly one hundred dollars a pound

A new era in malarial therapy followed the introduction of cinchona, and researches as to its application were soon forthcoming Barba, a Spanish physician, was first to write of its merits in 1642 at Seville. By 1651 physicians in Rome fixed the dose of the powder at two drams, recommending the use of laxatives beforehand. Not long after that the British physician, Sydenham, decided to prescribe cinchona just after the first attack to lessen, or prevent, a second paroxysm. Soon Sebastian Badio, impressed with the superiority of the medicine, published a dissertation in 1663 In 1679 the Englishman Talbor introduced his method of treatment in France and successfully treated the dauphin. Subsequently, Louis XIV purchased his secret remedy for 80,000 livres and an annuity of 2000 crowns. Later, when the king himself was seized, he recovered with the powder administered in wine. Up to this time the specificity of cinchona for malaria had been disregarded, but now fevers could be separated into those which the bark cured, and those which remained unaffected by it.

Comparable to the progress which had been made in the treatment of the disease was the advance made in the classification and cultivation of the trees. LaCondamine contributed one of the early studies in 1738, the results of which he published in the memoirs of the Academy of Sciences His descriptive report enabled Linnaeus to trace the characteristics of the genus, which he named cinchona in memory of the Countess of Cinchon. Soon botanists discovered other species, the more outstanding investigators being Mutis, Ruiz, and Pavon.

Following these discoveries, another advance was made when, in 1820, the French pharmacists, Pelletier and Couventou, isolated quinine from the bark. Pelletier read their paper on "Chemical Researches on Cinchonas" that same year before the Academy These workers proposed the name "cinchonine" for the gray and yellow bark, and "quinine" for the red bark Some years must still pass, however, before the beneficial effects of quinine could be completely realized for, as Sir Richard Burton soon wrote:

> How short this Life, how long withal;
> how false its weal, how true its woes,
> This fever-fit with paroxysms to mark,
> its opening and its close

There now came a time when cinchona plantations became necessary so as to supplement the nearly depleted South American supply. As early as 1792 Ruiz advanced the idea of cultivating trees outside their native regions Still it was not until 1848 that Weddell brought seeds from South America to France, and strenuously argued in favor of plantations. His seeds were planted in the Jardin des Plantes, Paris, and by 1850 the young plants were shipped to Algeria. Two years later seedlings were sent to Java where the Dutch made the first important attempt to cultivate the trees Soon the British government sent Clements Markham on a Peruvian expedition to obtain seeds for southern India and the island of Ceylon. Through these and other early efforts an adequate supply of quinine of high quality soon became assured.

Although by the middle of the nineteenth century an improved understanding of malarial fevers and their treatment had resulted, the nature of the causative organism still remained unknown. Rasori, however, had recently advanced the idea that intermittent fevers were caused by parasites, and that the paroxysms resulted from their peri-

odic reproduction. From a somewhat less scientific standpoint Burton, in 1856, wrote in his *First Footsteps in East Africa* that the natives of Somaliland thought mosquito bites caused fevers. He explained this belief as a superstition which resulted from fevers and mosquitoes being present at the same time. Livingstone, a year later, mentioned in *Missionary Travels* that fever sometimes follows insect bites Again, in 1865, he wrote in his *Narrative of the Expedition to the Zambesi* that mosquitoes indicated the presence of malaria. More scientifically, Klebs and Tomassi-Crudeli, in 1879, found what they thought was the cause of the disease. They had discovered a bacillus in the Roman marshes which, when injected into animals, produced a fever similar to malaria. They proposed the name *B. malariae* for this organism, and it remained the accepted pathogenic agent until 1880 when the French army officer, Laveran, made his epochal discovery of malarial parasites in the human blood Five years afterward Golgi demonstrated the tertian and quartan life cycles, at which time Marchiafava and Celli made related studies. Then, in 1895, Ronald Ross in India made the observation that the parasites developed in the mosquito, a finding which was predicted by Manson a year earlier.

By the close of the century, then, malarial fevers were well understood, the drug quinine had become the recognized specific for the disease, and the plasmodium had recently been identified Progress had also been made as far as drainage of swamps and screening of dwellings were concerned, which favorably affected the incidence in some areas However, despite these distinct advances in the understanding and control of the disease, malaria has continued to constitute a serious medical problem. Not only has it remained among the afflictions of civilian populations, most especially in the tropics, but it has presented a formidable problem among the armed forces in time of war.

Not the least enemy to be reckoned with in the Spanish-American War was the anopheline mosquito. So, too, malaria was one of the diseases which made the building of the Panama Canal almost as much a problem of medicine as of engineering. In this respect, James Stanley Gilbert's "Panama Patchwork" recalls its frequent consequences:

> Close the door—across the river
> He has gone.
> With an abscess on his liver
> He has gone.
> Many years of rainy seasons
> And malaria's countless treasons
> Are among the many reasons
> Why he's gone.

Still more recently, with the opening of the eastern front during World War I, the malady reached epidemic proportions—the British forces alone reporting over 300,000 cases in the course of three years of hostilities.

What toll this age-old affliction may take during the current global conflict no one can safely predict. Yet, with the tropical regions once more constituting major theaters of war, it is clear that malaria is, and will be, a further enemy affecting military plans Especially is this true now that the Dutch East Indies, normally the source of ninety per cent. of the world's supply of quinine, are enemy possessions. Fortunately, certain synthetic substitutes are available, such as atabrine, now officially recognized under the nonproprietary name of quinacrine.

STATUS AND PROSPECTS OF CLIMATOLOGY

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Introduction

METEOROLOGY consisted originally of knowledge of all phenomena of the middle space between the earth and the heavenly spheres but came in time to mean knowledge of the atmosphere alone As meteorology took definite form as a science in the nineteenth century its content became still further restricted. For nearly a century the primary concern of the meteorologists has been the phenomena comprised in the term "weather"; that is, irregular short-time fluctuations in the state of the atmosphere So close is this identification of meteorology with knowledge of weather that the science is often regarded as merely a technique whereby the irregular changes of weather can be predicted.

Through its exclusive association with weather, meteorology has lost an important part of its former content This lost content has to do with the regularly recurrent or periodic changes in the physical state of the atmosphere, from day to night and from summer to winter The seasonal rise of temperature in spring is a climatic phenomenon, recurring every year; its average rate, and the temperature to be expected at any particular date, are elements of the local climate. The conditions of the atmosphere expected at any place on the basis of experience constitute its climate. It is climate, therefore, that has been lost from view as it assumed its present state Meteorology has ceased to concern itself greatly with the knowledge of climate; it has, in fact, tended to become merely "weatherology," although climatology is still claimed as one of its constituent parts.

While the public has been given an ever more elaborate weather service, the scientists and administrators who are responsible for the long-time trends of public policy have not had the climatologic counsel they might have found useful. Agriculture, for example, has long been the object of solicitous attention on the part of Federal and State agencies These agencies have encountered climatologic questions at many points and at frequent intervals, just because they have so often directed their activities toward changing the routines followed by farmers That such matters as the introduction of new crops, the control of harmful insects and plant diseases, the introduction of farming practices for the prevention of erosion, and the resettlement of drought-stricken farmers have a close dependence on climate is well known to the specialists who work with them.

Nevertheless, the climatic aspects of these problems are handled vaguely and their critical relations remain to a large extent undefined. There has been no group of specialists in climatology that might have provided both example and counsel for the treatment of the climatic factors in problems of such general concern.

Climatology in the United States

A century ago meteorology was mainly climatology. Weather records were analyzed by the well-established methods of astronomy. The daily and annual march of various weather elements were seen to be related to the astronomic motions of the earth, and it was believed that behind the irregular fluctuations there was regularity of recurrence com-

parable to the regularity of the motions of the planets. Accordingly, the essence of climatology was thought to be averages or normals, and numerical expressions for regular recurrence. Joseph Henry, in 1855, stated that the irregular weather fluctuations could be identified and studied in terms of the regularity of climate.

> We . . . need not, in this branch of knowledge, . . . be confined to the mere discovery of the existence, and the measure of the constants of nature, but, uniting the results of observations with those of experiments in the laboratory, and mathematical deductions from astronomical and other data, we are enabled, not only to refer the periodic changes to established laws, but also to trace to their source, various perturbing influences which produce the variations from the mean, and thus arrive, at least, at an approximate explanation of the meteorological phenomena which are constantly presented to us.[1]

Before his time others had already discovered that the arithmetic treatment of meteorologic observations did not lead to results as satisfactory as were obtained from astronomic observations "On the one hand," wrote a Swedish scientist in 1824, "is the most regular order to be found in Nature, on the other, to the best of our present knowledge at least, the most confused variability, so that we see no way in which any common periodicity may be found"[2]

A distinct change from the methods of astronomy came with the introduction of the synoptic view of weather, which takes account of conditions occurring simultaneously over a large area Almost as soon as weather observations began to be available for a large number of places in eastern United States the study of individual storms commenced, and information on their size, form, and rate and direction of travel began to accumulate. The invention of the telegraph made it possible to bring together quickly weather observations made simultaneously at a number of places and to determine the position and characteristics of individual storms on successive days. During the 1870's, when the possibilities of this procedure became evident, public demand for weather forecasting led most countries to establish official meteorologic services. In the United States they began on November 1, 1870,[3] under the control of the Signal Service of the Army. This move made of meteorology an official technology, if not an "official science," as it has sometimes been called. The attention of meteorologists was shifted; whereas in the 1820's the object of investigation by the science of meteorology was "climate," by the 1870's it had become "weather."

Even though the public meteorologic service of the United States remained in the War Department for two decades, it established during that time several special services for the benefit of agriculture, prominent among which was a system of frost warnings. In 1891 the Service was at length transferred to the Department of Agriculture, under the name "Weather Bureau."

In both institutional and individual study of the atmosphere, the importance of climatology to agriculture was recognized throughout the nineteenth century. Lorin Blodget's admirable *Climatology of the United States* . . , published in Philadelphia in 1857, contained chapters on the relation of native and cultivated plants to climate, and the bulk of the book deals with climatic limitations to the agricultural development of the

[1] Joseph Henry, "Meteorology in its Connection with Agriculture" In Report of the Commissioner of Patents for the year 1855, p. 358. Washington [D. C.] (34th Cong., 1st Sess., H. Ex. Doc. 12.)

[2] Frih. Ehrenheim, "Om climaternes rörlighet" (Stockholm, 1824: 206).

[3] The best account of the development of meteorology in the United States until the early nineties of the last century is contained in a series of papers issued as Report of the International Meteorological Congress, held at Chicago, Ill., August 21–24, 1893, under the auspices of the Congress Auxiliary of the World's Columbian Exposition, *U. S. Dept. Agr., Weather Bureau, Bull. No. 11, Part II*, 1895, pp. 207–335.

western half of the United States, which was then awaiting settlement. The meteorologic organization within the Signal Service also contributed to public knowledge of the climate of the new western lands, through the preparation of a number of reports of which the following are illustrations: "Rainfall of the Pacific Slope and the Western States and Territories," 1888; "Climate of Oregon and Washington Territory," 1889; "Climate of Nebraska, Particularly in Reference to the Temperature and Rainfall and their Influence upon the Agricultural Interests of the State," 1890; and, after the transfer of the Service to the Department of Agriculture, "Certain Climatic Features of the Two Dakotas," 1893

These publications were a part of the scientific stocktaking of the new lands of the West, comparable to the contemporary work of the Geological Survey. Together they made a profound impression on American natural science More intensive investigation of the relations between climate and agriculture is reflected in "Tables of Rainfall and Temperature Compared with Crop Production" (Signal Service Professional Paper 10) 1882, and in some of the early bulletins of the Weather Bureau, among which are to be found: E W Hilgard, "A Report on the Relations of Soil to Climate" (W B. Bul. 3), 1892; Milton Whitney, "Some Physical Properties of Soils in their Relation to Moisture and Crop Distribution" (W B Bul. 4), 1892; P. H. Mell, "Report on the Climatology of the Cotton Plant" (W. B. Bul. 8), 1893; and Cleveland Abbe, "A First Report on the Relations between Climates and Crops" (W. B. Bul. 36), 1905, which was actually written in 1891. Although these reports are also very general, they suggest lines for further research.

A large fraction of the total effort put forth by the Weather Bureau is now, as always, expended on the collection, compilation and publication of climatologic observations. This work is absolutely essential. It is, however, an extremely laborious task that is easily put aside. Concerning this the first chief of the Weather Bureau once said:

> The number of observations involved is so enormous, the necessity for accuracy so increases the amount of work, and after the compilation the reduction of the results into a lucid form, capable of easy reference, is itself so slow a process, and such work seems so suitable to be displaced by other work more urgent but less important, that progress is very slow [4]

It is easy to understand why little energy remains for the analysis and interpretation of these data and especially for the study of special climatic problems

At its inception the Weather Bureau was charged with "the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States" In carrying out this responsibility it was necessary to introduce rigid standardization of its instruments and of the manner in which they are exposed. The Weather Bureau has had, moreover, to keep the number of cooperative climatologic stations within manageable limits. The net of cooperative stations is close-meshed enough over most of the country to permit the drawing of good general maps of the climatic elements, but it is not and can not be dense enough to reveal the local differences within the larger frame of climatic contrasts that are important to growing plants These local climatic relations slip readily through the meshes of the existing net of climatologic stations.

Microclimatology

A standardized system of climatologic observations, although the only kind that can be used for the general purpose of establishing and recording the climatic conditions of an area as large as the

[4] Mark W. Harrington, "What Meteorology is Doing for the Farmer." In Yearbook of the U. S. Department of Agriculture, 1894, p. 119, Washington [D. C.], 1895.

United States, can not be expected to provide answers to climatologic questions that arise in relation to the production of the many kinds of crops and the other varied agricultural activities in so large an area For one thing, the climatic elements that affect different crops in different parts of the country are not the same For another, the standardized observations for the purposes of synoptic meteorology or for general climatologic purposes seek to avoid the local influences of vegetation and soil as completely as possible, whereas, what is required for agricultural and biological purposes are observations near the ground in the zone where the plants actually live.

The climate of a region as determined by means of the standardized observations is more or less of an abstraction. Actually the region is a composite of innumerable local climates; the climate of the ravine, of the south facing slope, of the hill top, of the meadow, of the cornfield, of the woods, of the bare rocky ledge. These local climates may vary greatly among themselves. For example, the climates of adjacent north- and south-facing slopes may resemble in many respects the standard climates of places hundreds of miles away to the north and south.

Furthermore, the climate five feet above the ground in a standard weather shelter is very different from that within a few inches of the ground in the open. Nocturnal temperatures are lower and daytime temperatures are higher near the ground than a few feet above it. For example, the range in mean monthly minimum temperature is as great within five feet of the ground vertically as in a belt 300 miles wide from north to south at the standard level. Diurnal variations in moisture concentration are much greater within an inch of the ground than at the height where the standard observations are made Wind velocity increases with height; when it is nearly calm near the ground the wind may be quite strong five feet above.

The climates of areas of very limited extent are called microclimates. They are clearly the ones that concern the farmer, the agronomist, and the biologist. The standardized climatologic stations are neither situated nor equipped to measure temperature or humidity at the places and at the times that are critical for crop plants. It may be confidently stated that few problems that involve relations between living organisms and climate can be solved without special procedures in observation and in the treatment of observational data When light on such problems is sought in the observational data as they are published, it is generally sought in vain.

The standard observations do not, as has been supposed, give an average of climatic conditions over a considerable area. They are in themselves microclimatic observations, and may differ appreciably from representative conditions, depending on the nature of the microclimate in which they are taken. The temperature regime in a standard shelter at standard height above the ground gives no measure of the range of temperature conditions at different heights over a considerable area.

The general climatology of the United States and the pattern of climates over the earth have been pretty well understood for a long time. Good maps of the climatic elements have been prepared and considerable progress has been made in the classification of climates. It is certainly worth while to refine and revise the climatic maps and to improve the classifications.

The most important present task, however, is in the field of microclimatology. For the biologist it is more important to know the pattern of climatic distribution between the ground and the tree tops or the pattern over a field or a farm than it is to know the world pattern. The facts of microclimatology are subject to

systematic generalization just as are those of general climatology; it is the responsibility of the climatologist to obtain these facts and to make the generalizations.

Rough correlations are actually found between the published standard climatologic observations on the one hand and the behavior of organisms of economic importance on the other. That such correlations are found at all signifies that in the particular relations studied the available climatic data run more or less parallel to the values of the climatic elements that are critical. For example, the summer precipitation collected in a standard raingage may be roughly proportional to the soil water accessible to the root hairs of crop plants growing in the immediate vicinity. The maximum and minimum of temperature recorded within an instrument shelter on successive days probably march approximately parallel to the temperature inside the husks of an ear of corn Only if an investigator is lucky, will the proportionality or parallelism be close enough to be of use.

For nearly two centuries investigators have been seeking for relationships between plant development and various factors of climate and many times it has been shown that available climatologic observations can not be expected to yield satisfactory results One of the clearest statements of this viewpoint was made by Köppen in 1871, in an investigation of heat and plant development He said:

> I believe that this last consideration serves to destroy the beautiful illusion that it is possible to represent the development of plants, even those of a single species, by means of a general formula which contains temperature, light, humidity and other external agents as factors But, to be sure, whoever finds illusion more pleasant than sober knowledge is not disturbed by such considerations; so he goes on his way in peace and it is no fault of his if others can not follow him.[5]

[5] Wladimir Köppen, "Waerme und Pflanzenwachsthum," *Bull. de la Société Impériale des Naturalistes de Moscou*, Vol. 43, 1871, p. 110.

There are innumerable current examples of failure to solve important agricultural and biological problems because of the inadequacy of existing knowledge concerning local climates. Here are only a few.

An entomologist has been searching for the climatic elements that may control the distribution and spread of the European corn borer If the climatic range of the insect could be identified, a costly quarantine might be relaxed, and much public money saved. This entomologist has proved that climate and weather are the principal variable factors responsible for the distribution and spread of the insect. However, he has failed to find any relations, that can serve practical ends, between the behavior of the insect and any of the standard climatologic observations that are available.

A cereal chemist is studying the protein content of wheat in connection with an important problem in human nutrition He has found that protein concentration varies from county to county, and from year to year at the same place, and has evidence that differences in climate and weather are responsible for these variations. The detailed climatologic observations that are necessary to determine the climatic controls have not been made.

An agronomist wished to determine the influence of climate on the variation of yields of several crops over a period of years on fields having a single soil type. The climatological data available included only maximum and minimum daily temperature and daily precipitation. It became clear that these observations made according to standard procedure at one place in an area of over 200 square miles had little connection with the life processes in the multitude of individual plants comprising the crop.

An agronomist finds that alfalfa seed develops well in some districts but not

in others that have the same kind of soil. He believes that these differences are due to local differences in climate, but he is unable to determine what they are.

A forester is faced with a high mortality among seedling trees in an important afforestation project. He was unaware of the fact that the climate near the ground is very different and much more severe than is indicated by temperature observations made within a shelter at standard height

The solution of such special problems obviously requires a program of observation designed for the express purpose of tracking down the critical climatic factors and measuring them at the particular place and time where and when they are effective. Plants and animals live by maintaining an equilibrium in the exchange of matter and energy with their environments The matter and energy involved in their direct climatic relations consist primarily of water and heat. A little too much or too little in an essential organ at a particular time—that is all that may be needed to destroy the plant or animal. It is not to be expected that the standard exposure of standard instruments should yield more than an exceedingly rough indication of the values of the climatic elements at the points in space and the moments in time where and when they count most in the life of organisms.

Damage from frost is one of the most direct and simple relationships that exist between a climatic element and a plant. The adverse effect on the plant is due not to a lack of sufficient energy to permit normal development but rather to a definite destruction of plant tissue. In its frost-warning services in fruit-growing areas, the Weather Bureau has set up special systems of instrumentation that depart widely from the standardized type. This service is an outstanding example of what can be accomplished by developing special observations for special purposes.[6] If special instrumental installations are required for study of the relatively simple effect of frost on plant development, they are all the more necessary in the investigation of the more obscure influences, such as the effect of high temperature or drought on crop yield.

Each problem requires study from the climatic as well as from the biologic side. Special exposure of instruments, sometimes the construction of special instruments, always the special handling of observational data are required. Each organism has its own rhythm that is at least in part independent of the calendar. Observational data must be grouped according to the phases of the life cycle of the organism The most useful method of organizing climatic data can be found only through study of that life cycle. The task is not one for the biologist alone nor for the climatologist alone, but for both in collaboration.

To that collaboration the biologist can bring his previous knowledge of the organism and his techniques for obtaining more knowledge about it The climatologist can bring his knowledge of how temperature and humidity vary within distances that are small in relation to ordinary meteorologic observation, but significant to a plant or an insect; of how instruments may be installed, and if necessary devised and constructed, so as to give the observational data needed; and of how these data may be handled so as to yield the maximum of insight. In order to be most useful in a collaborative study the climatologist must obtain more information than is now available on the climate of the layer of the atmosphere next to the ground; he must know

[6] Nearly forty years ago a microclimatic study on "Frost and Temperature Conditions in the Cranberry Marshes of Wisconsin" was made by Henry J. Cox, of the Weather Bureau. This was a magnificent pioneer effort along new lines, and it is a great misfortune that it was not followed up with many other similar studies.

how temperature, moisture, and wind vary with height above the ground, within the cover of vegetation and immediately above it, and he must be able to say how the vertical gradients of temperature, moisture, and wind vary through the day and from season to season.

It is scarcely necessary to remark that a mutually satisfactory job of collaboration inevitably leads to the discovery of more jobs to be done. It is equally self-evident that procedures devised for one task would, when they became known, stimulate the application of the same or related procedures to other problems New observations and new manipulations of observations lead to new insights into purely climatologic questions

The climatic aspects of problems in many fields that have no concern with biologic phenomena are likewise handled vaguely and remain essentially undefined because of the inadequacy of our present knowledge of climate For the heating and ventilating engineer, a knowledge of the microclimates of a city is essential. The variation of temperature, moisture and wind with height as well as horizontally is enormously complicated by the structure of the city itself and the many disturbances which it creates. The climate at the tenth story level near the heart of a city will differ in many respects from the climate in a residential community in the suburbs, and the standard climatologic observations will probably not be representative of either situation In the parts of the country where fuel is rationed, the application of a uniform formula that takes no account of microclimatic variation, will bring much more discomfort to some people than to others Similar illustrations could be drawn from hydrology, highway engineering, medicine, military science and many others.

In the practical application of meteorology to weather forecasting, climatology can be of much service. The normal diurnal and annual march of means of the climatic elements are of great value in the interpretation of the synoptic weather map. Most important in the formulation of detailed local forecasts are statistical analyses of the climatic data to determine the probability that individual weather elements will depart from the normal by specified amounts

An Institute for Climatic Research

There is at present no agency in the United States that is in a position to offer the assistance asked for by scientists who, in the prosecution of their investigations, encounter climatic problems In the Federal Government, neither the agencies where the problems involving microclimatology arise, such as the Bureau of Plant Industry, the Forest Service, the Soil Conservation Service, nor the Weather Bureau where the task of obtaining standardized climatological observations has been so conscientiously performed, possess the facilities for assuming leadership in this new field. Nor do the present resources of the State agricultural experiment stations permit them to take the lead in applied climatology.

The courses in climatology that are found in many universities and colleges have usually been established and are usually maintained by departments of geography Geographers have been interested in the science of climatology almost exclusively as a key to the regional differentiation of the earth and consequently have concentrated on descriptive climatology and on the classification of climate. To them the prime purpose of climatology has been to reduce the baffling complexity of climate to a system that would explain the differentiation of the earth's surface with respect especially to biological phenomena.

Much of the current literature of climatology is written by the geographers. The data of observation published in convenient form by the meteorological offices of the various countries invite further working up and generalization. This easily accessible material will provide the means for refinement of climatic maps and for comparable work during an indefinitely long future. The study of descriptive climatology has, thus, been diligently pursued and bulletins and monographs on the climate of particular regions and places are numerous. Honest and useful as much of this work is, it seldom gets down to sufficient detail to be of use in individual practical problems.

The fact that climatology has in the past been largely descriptive and is not now developed to a point where it can contribute to the solution of the many urgent practical problems in agriculture and biology is in part a consequence of the departmentalization of knowledge in colleges and universities. Facility in the development of instruments for measuring the climatic elements demands knowledge of physics and mathematics; and facility in the analysis and interpretation of climatic data, once they are obtained, requires a knowledge of statistics and meteorology. But biologists do not ordinarily study physics, mathematics, and statistics. Geographers, who have a very real interest in climatology, usually study neither physics and mathematics on the one hand nor biology on the other. Physicists are absorbed with their own special problems and are not aware of the acute need that others have for the assistance that they could give. In our universities today, courses of study are so inflexible and prerequisites so extensive that it is difficult in a four-year period for a student to get the training that would lead to competence in physical climatology.

It appears, therefore, that there is a place in the United States for a new agency, an institute for climatologic research. Such an institute can scarcely come into existence fully formed and fully armed, but must attain its final character gradually through the work it accomplishes. It would be sufficient as a beginning to have assurance of the continuous support for several years of a staff of two or three professional workers and their clerical assistants. Even ultimately the permanent staff would not need to number more than five or six.

The institute should be affiliated with a first-rate university which includes an agricultural college and experiment station. This would provide its first and most important connection. It would also have connections with agencies of the Federal Government, particularly the several bureaus of the Department of Agriculture Most of the research undertaken would be collaborative; and while that work was in progress representatives of agencies situated elsewhere might be temporarily in residence at the institute. Members of the institute's staff should also be moderately foot-loose, so that they might visit other institutions when occasion arose.

In addition to their collaborative work in applied climatology, members of the permanent staff would have their own research problems, which would usually be problems in physical climatology. Reworking and interpreting the data published by the Weather Bureau will always provide work for many persons and the staff of the institute would participate in that work of interpretation. Of more importance are tasks that are not likely to be touched by the Weather Bureau. One such task is the development of instruments and methods of observation of temperature, light, humidity and wind, as actually experienced by plants growing under natural conditions. The installation of instruments in dense nets over restricted areas in order to investigate local problems is another. A third is the application of

statistical procedures to climatic data by means of which new meaning may be extracted, and the devising of new statistical procedures adapted to this end.

Many of the jobs undertaken in collaboration with nonmembers of the institute would raise physical and statistical questions that could be answered only by special investigation. When a permanent organization is attained, the staff of the institute would include a member having special competence in statistics, another particularly skillful in the devising of instruments, and so forth. Each member of the staff would usually have at least two research problems going on at the same time: one in his own field of physical or statistical climatology, the other in applied climatology carried on in collaboration with a specialist in another field.

An exceedingly important task of the institute would be the training of climatologists. This consideration is a further powerful reason why the institute should be articulated with a good university. The training offered would be on the graduate level, as is the professional training in meteorology given at several institutions in the United States An attempt would be made, however, to avoid overspecialization Since the institute would emphasize collaborative research, students would be expected to acquire a rather broad acquaintance with other sciences They would be asked to acquire, if possible, a more than superficial knowledge of some field besides climatology, so as to be equipped to work with specialists in that field This subject might be one of the specialized biological sciences such as entomology or plant pathology, a branch of engineering, economics, or medicine. The student's specialized preparation for graduate work in climatology would be heavily weighted with mathematics (including statistics), physics, and meteorology. Since graduate students with a wide range of backgrounds would apply for admission, the schedule of prerequisites would need to be flexible. The institute would rely on existing personnel in the regular departments of the university to provide undergraduate training. The institute's staff would, therefore, include professors from these various departments in addition to its full-time members

The principal outlet for trained climatologists, at least in the beginning, would be in such Federal agencies as the Weather Bureau, the Soil Conservation Service, the Forest Service and the Bureau of Plant Industry, whose work touches climate at many points. A large proportion of the students might be young employees of these organizations on leave or on detail, who would return to their respective bureaus at the end of their training. If the institute proved to be as useful in the scientific world as our experience leads us to expect it to be, men with the training it afforded would soon be in demand elsewhere than in these Federal agencies. Once the potentialities of applied climatology were demonstrated, every agricultural college and experiment station would have use for at least one climatologist His job would be to work with the agricultural specialists in the solution of their climatologic problems and to give students a practical knowledge of climate

We have in the United States an example, in meteorology, of the fruitfulness of initial assistance in the establishment of instruction and research in a subject poorly represented in the universities. From a small beginning made possible by modest support from an educational fund has come a renaissance of synoptic meteorology that has brought back to the United States the leadership in the field it established and held fifty and sixty years ago. In its own way climatology promises an equally rich return.

THE PROGRESS OF SCIENCE

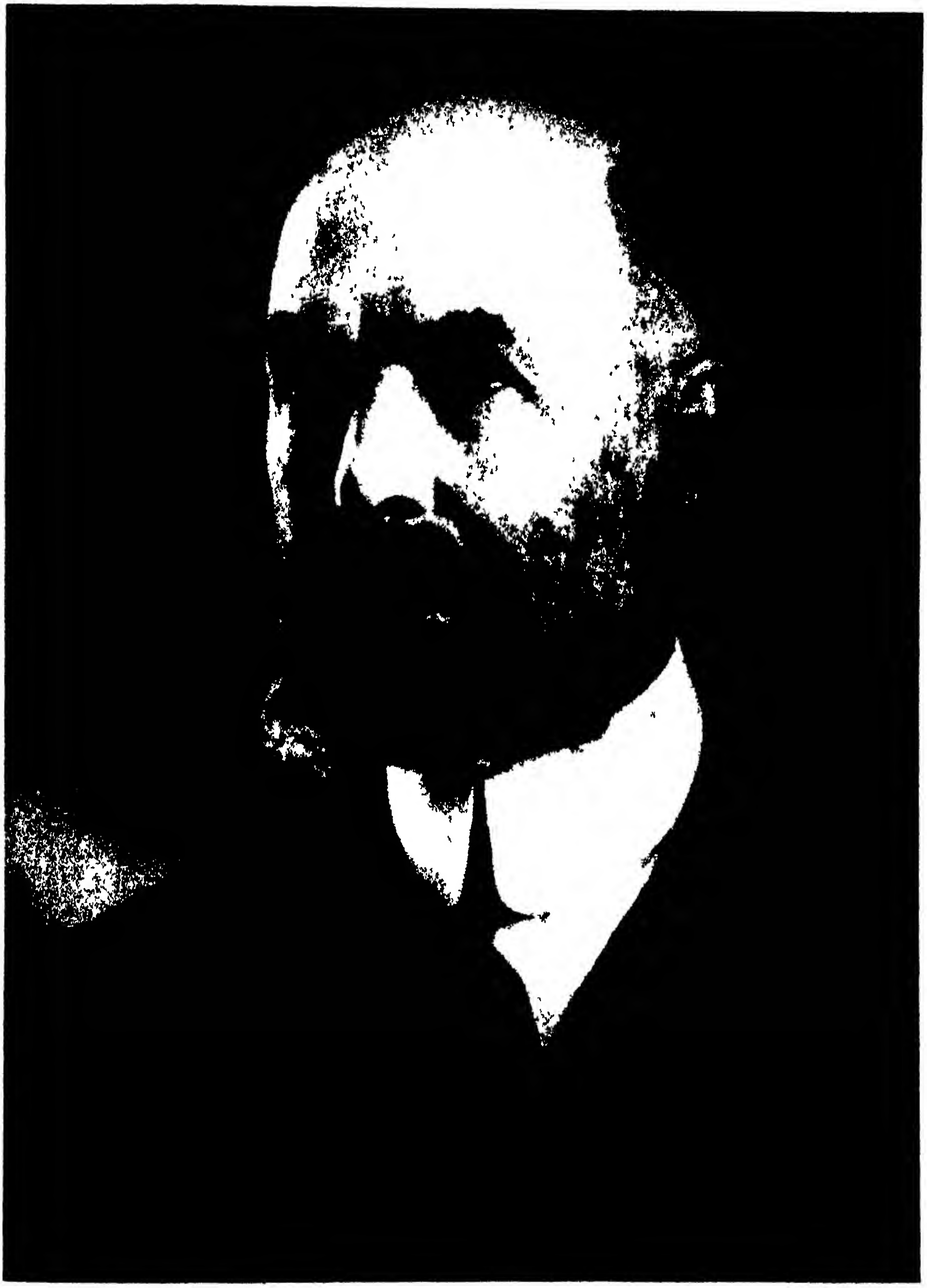
WILLIAM FOGG OSGOOD AND AMERICAN MATHEMATICS

WILLIAM FOGG OSGOOD, Perkins Professor of Mathematics, emeritus, in Harvard University, died on July 22, 1943, at his home in Belmont, Massachusetts He was one of the outstanding figures in the group of Americans responsible for the notable development of American mathematics which began about 1890 Inspired by European study, mainly in Germany, these men set out to do their utmost to foster mathematical scholarship and research at home. Among these, E. H. Moore of Chicago, Osgood and Bôcher of Harvard, E. B. Van Vleck of Wisconsin, White of Vassar, and Pierpont of Yale were destined to become leaders by virtue of their mathematical accomplishments; others too, like Cole and Fiske of Columbia, and Fine of Princeton, also rendered service of the highest value to the cause of American mathematics

Osgood was born on March 10, 1864, in Boston, a direct descendant of one John Osgood who came to Ipswich, Massachusetts, in 1638 As an undergraduate in Harvard College, Osgood received his first scientific stimulus from B. O. Peirce, a mathematical physicist of distinction After his graduation in 1886 there followed one graduate year in Cambridge, Eng , and three fruitful years of mathematical study in Germany where Osgood came under the influence of a great mathematician and teacher, Felix Klein, and underwent what can best be characterized as a *conversion* to German-European ideals in the mathematical field. These were naturally congenial to his thorough-going and systematizing temperament Thus there opened a veritable new world to the young Osgood Indeed Klein, organizer in the nineties of the remarkable German Mathematical Encyclopedia, not only determined the direction of his later scientific development by asking him to write the article in the Encyclopedia on "functions of one or more complex variables" but, it may be suspected, furnished an exemplar which Osgood emulated as teacher, as investigator, and as man

After his European sojourn, Osgood became a member of the mathematical staff at Harvard University and so continued throughout his entire active academic life He might have gone elsewhere, had he been less devoted to New England, to Harvard and, above all, to its Department of Mathematics. Of the honors received by him here and abroad, perhaps there was only one that really meant much to him—his election as eighth President of the American Mathematical Society (1905–06) Osgood might have said in justification of such an attitude· "In our Society there has been a sustained scholarly tradition on a high level, to which I have given my utmost. I am honored to have my mathematical work so recognized by this body of friends and colleagues with ideals like my own " The same type of realistic analysis, ruthlessly applied, led him to discount heavily, and even to be averse to, honors which were generally appreciated by others

His teacher, Klein, was not himself a logical thinker of arithmetic type, being inclined to an intuitive, more geometric mode of reasoning. Yet he saw that Osgood was just the right person to construct a satisfactory basis for the geometric methods which Riemann had used in the field of functions of a complex variable and which were notably lacking in Weierstrass's wholly non-geometric but rigorous approach based on power series. It was the splendid fulfillment of this important task which absorbed most of Osgood's scientific life.



WILLIAM FOGG OSGOOD, 1864–1943

His *Lehrbuch der Funktionentheorie* of 1907 was the principal outcome, containing his most significant work in the field. This volume, which has gone into five editions and to which two supplementary volumes were later added (1924, 1932), for decades served everywhere as an unrivalled treatise on the subject It is still unsurpassed as a basic text, although an even more geometrical (*i e.*, topological) point of view is expounded in recent modern books based on the work of the Finnish school. Without exaggeration it may be said that this work of Osgood is "one of America's greatest contributions to the develpment of mathematics."[1]

The reason why this book appeared in the German language instead of English lay in a certain characteristic hard-headedness of the author. Osgood then felt, probably correctly, that if the book were to be published in America, it would be less widely used; and so he decided to publish it under German auspices. The widespread favorable reception of the book by the mathematical public, and the fact that no pressure ever developed in this country to have the work translated into English seem to have justified Osgood's decision at the time he made it, although the conditions for American mathematical publication have since become excellent. It fell to Osgood himself, during two very interesting years after his retirement in 1933, when he served on the staff of the National University of Peking, to produce a simplified English version of the first volume of his treatise.

Osgood's unrelenting mathematical practicality lay at the basis of his mathematical successes and explained his limitations as well. In his first paper of consequence, published only in 1897 when he was thirty-three years of age, he took a significant step in the direction later to be followed by Lebesgue (1904) which led to the Lebesgue integral, of vital importance in modern analysis The reason why Osgood went no further was that the classic Riemann integral sufficed for the kind of problem which he was considering at the moment. Likewise Osgood felt that the so-called Heine-Borel theorem was a "process of thought" rather than a true theorem; here he manifested an almost perverse prejudice against purely abstract forms of mathematical thought. On the other hand, the same practicality led him to ask whether a Jordan curve has necessarily a null planar area, and so to construct an illuminating example of such a curve with positive area. Similarly, he saw that an ordinary minimum of a function has the obvious property that, for values of the independent variable differing by at least a certain amount from the value affording a minimum, the function will exceed this minimum by at least a specified quantity; this led him to "Osgood's theorem" in the calculus of variations which states that a like property holds for the minimum of integrals taken along a curve joining two fixed points Again, by means of a simple example, he showed that, even under very favorable circumstances, variables cannot be eliminated in the case of transcendental equations in the same way as in the case of algebraic equations; and thus he threw important light on some of the difficulties to be faced in the study of such transcendental equations

From the days of his undergraduate work with B. O. Peirce, Osgood always retained an interest in classical dynamics and physics. His vectorial treatment of gyroscopic motion (1922) simplified the subject by affording an elegant geometric approach to it.

His textbooks on the calculus, elementary and advanced, were perhaps the first to be written in the English language

[1] R. C. Archibald, *A Semi Centennial History of the American Mathematical Society, 1888–1938.* 1938, I, 155.

from a careful scholarly point of view, and have exerted a widespread influence. He also wrote a book on plane and solid analytic geometry (with W C. Graustein), and one on mechanics, both of which have been definitely useful. His primary motive here was to furnish a sound introduction to the student beginning the study of mathematics and its applications Osgood was always a capable and conscientious teacher at all levels of instruction, and, at least in the early part of his teaching career, painstakingly graded exercises in his courses.

Not many students were inspired by Osgood in their research work, and the reason is not hard to find. His method of attacking a problem was to make an exceedingly careful and systematic exploration of details, it was thus that his own creative ideas came to him after arduous effort It was natural then for Osgood to suggest to the prospective student desirous of working with him that he first make a careful preliminary routine survey of the field But the average student was discouraged at the very outset by the unaccustomed labor, which was thus required, without apparent reward.

The indebtedness of the Harvard mathematical tradition to Osgood and to his colleague and intimate friend, Maxime Bôcher (1867–1918), is very large indeed. These two men, more than any others, established our standards of scientific accomplishment, and saw to it that the younger men in the Department had the same privileges as the others, and an equal voice in the conduct of its affairs [2]

On the personal side Osgood was decidedly urbane, and made an extremely pleasant companion. It always seemed to me that, without much change of personality, he could have become a successful practical man of affairs Of course such a career would have held no interest for him

The American mathematical community generally, many former students, and his friends and colleagues will always remember with deep gratitude his single-minded devotion to the highest ideals of scholarship, and in so doing will be the more resolved to maintain for themselves a like elevated goal of idealistic achievement

GEORGE D BIRKHOFF

[2] See J L Coolidge, "Three Hundred Years of Mathematics at Harvard," *American Mathematical Monthy*, Aug., 1943

EPIDEMIC KERATOCONJUNCTIVITIS

IT is now more than two years since a non-bacterial keratoconjunctivitis appeared in epidemic form in continental United States. Since that time the disease has temporarily incapacitated many workers engaged in important war industries, and in a significant percentage of cases has inflicted semi-permanent or permanent corneal damage sufficient to remove the individuals from the ranks of skilled workers.

The first area to feel the effect of the keratoconjunctivitis was the West Coast [1] Because the disease, if unchecked, appeared to have a high non-effective rate, and because it appeared capable of spreading over a large area, its progress was observed with some trepidation. An intensive investigative program (initiated by the Division of Preventive Medicine, Office of the Surgeon General; and the Commission on Neurotropic Virus Diseases, Board for the Investigation and Control of Influ-

[1] M. J. Hogan and J W. Crawford, *Am. J. Ophth.*, Sept., 1942.

enza and Other Epidemic Diseases in the Army) appeared justified when epidemic keratoconjunctivitis spread from the West Coast to New York City, where it soon affected hundreds of individuals About this same time, cases were reported from the Albany-Schenectady area in numbers which approached epidemic proportions. On the West Coast the disease persisted in endemic form In the East, it has left its mark along the entire length of the coast and has travelled as far south as Florida, and inland to Texas and Chicago.

There are certain differences between the Western and Eastern outbreaks which may be noted, since a comparison of statistics and clinical data suggests that the disease increased in virulence during its travel from west to east In California, the patients were usually incapacitated for one or two weeks and the complication of corneal opacities appeared in forty to seventy per cent of the cases In the East, on the other hand, subjective symptoms were distressing in the majority of cases and the acute, incapacitating stage frequently lasted two, three or more weeks Opacities were observed in as high as eighty-five per cent of the cases. Furthermore, the objective clinical appearance seemed to be more severe with particular reference to edema and tearing However, it should be emphasized that in spite of minor variations, the diagnostic features appear to be constant from epidemic to epidemic

At the present writing there is reason to believe that the problem of epidemic keratoconjunctivitis has become less pressing It is, of course, impossible to prophesy what the future may bring—whether the disease will follow a course of increased virulence or whether it will retreat into a relatively harmless state

The clinical picture characteristic of epidemic keratoconjunctivitis is as follows There is an acute conjunctivitis in which edema, especially of the upper lid, is predominant. The conjunctivitis may be follicular and hyperemia is marked. The follicular hypertrophy is probably due to a localized increase of lymphoid cells within the stroma of the conjunctiva,[2] and results in the appearance of small areas of glistening, raised mucous membrane At this stage patients frequently complain of a foreign body sensation and while lacrimation is marked, secretions are minimal It is not unusual for the symptoms to appear before there are marked anatomical changes However, the follicles are often disguised by edema and lymphoid hyperplasia occurring in the diffuse cellular elements in the deeper connective tissue. The anatomical result in the event of deep lymphoid hyperplasia is a massive outpouching of the palpebral mucous membrane, dramatically apparent when the lower lid is pulled down Bulbar involvement is usual and the chemosis may be so severe that bulbar mucous membrane projects between the lids A fully developed severe case of epidemic keratoconjunctivitis presents a fearsome picture

Associated with these signs and symptoms is a lymphadenopathy of varying degree, which involves the preauricular or cervical and submental glands Tenderness may be extreme and chewing quite painful It is not unusual for patients to complain of pain, apparently referred along the mandible. The lymphadenopathy may be present for only a few days or may persist for weeks after the acute signs have subsided.

Conjunctival scrapings made during the acute phase of the disease are not particularly significant They may show occasional lymphocytes or large mononuclears. However, if a secondary invader is present a polymorphonuclear reaction may be evoked. Bacteriological studies of the secretions are essentially negative and are either sterile or contain non-pathogenic organisms.

[2] Personal communication, Alson E. Braley.

The intensity of clinical signs and the severity of the disease vary greatly from patient to patient within the same epidemic and, indeed, within the same household. The majority of cases are unilateral In bilateral cases there is a tendency for the disease to be milder in the second eye. It may be noted that prognostications concerning the final outcome cannot be made on the basis of early clinical appearances

The most frequent and serious complication is involvement of the cornea which occurs from one to several weeks after the onset of the acute conjunctivitis (usually seven to ten days after onset) It is not unusual to see cases with severe conjunctival envolvement go on to spontaneous recovery in about ten days without development of corneal opacities On the other hand, a rather mild conjunctivitis may persist for weeks and be resolved by formation of many opacities with impairment of vision

It has been noted by workers at Johns Hopkins that some degree of staining with fluorescein occurs during the development of the opacities,[3] but it is generally agreed that when fully developed, they are subepithelial in character and do not stain Although the first sign that the cornea is involved may be pain or photophobia, in a surprising number of cases the infiltrates appear so subtly that the patient may notice only gradual blurring of vision

The outcome of the opacities varies On the West Coast blurred vision was generally transient. In the East, there was a tendency for the opacities to persist more often than they disappeared

In general, disability occurs for one of two reasons The patient may be unable to work because of ocular discomfort attendant upon an acute, severe conjunctivitis which lasts for one to three weeks. In the presence of opacities, vision may be sufficiently blurred to prevent the patient from carrying out his duties. The latter may last for much longer periods of time.

Since bacteriological studies in an obviously infectious disease were essentially negative, it is not surprising that a virus was suspected as the etiological agent In March, 1942, at the College of Physicians and Surgeons, a virus was isolated from the eyes of two patients suffering with epidemic keratoconjunctivitis[4] Later, four more strains were isolated under similar circumstances at the same institution[5] This work is in the process of confirmation

Epidemiological observations over the course of more than a year consistently point to contact infection as an important link in the chain of infection Whether this is the sole means of spread is not clear and the possible role of the carrier and of trauma must also be considered From the public health and industrial points of view, however, contact infection certainly is of prime importance Thus, the need is paramount for hygienic procedures in homes where individuals are infected and wherever patients are seen or treated Too many cases of disease transmission from patient to patient, from patient to physician, and from physician to patient have been authenticated to leave any doubt as to the importance of contact infection

In view of the consistent and frequently persistent lymphadenopathy, it was not surprising to find neutralizing antibodies against the experimentally isolated virus in the blood of patients recovered from the disease In a recent survey of more than three hundred serums certain data were obtained which may provide information on the problem of epidemic keratoconjunctivitis.[6]

[3] Personal communication, A E Maumenée

[4] M Sanders, *Arch Ophth*, Oct, 1943, Vol. 28, M Sanders, R. C Alexander, *Jour E Med*, Jan, 1943, Vol 77

[5] M Sanders, F D. Gulliver, L L. Forchheimer, R. C Alexander, *J. A. M A*, Jan, 1943, Vol 121.

[6] M Sanders, R. C Alexander—unpublished material

The tests were carried out by number and no clinical data were provided until the results of each test were known. Normal serum specimens were deliberately submitted with acute phase (where possible) and convalescent phase serums. While no neutralizing antibodies in the blood of normal individuals were demonstrated against the experimentally isolated virus, positive findings in four familial contacts suggest the possibility of subclinical infection. However, far too few "contact" serums have been done to warrant a definite statement on this matter. Of the authenticated convalescent specimens more than ninety-five per cent showed definite immune response which could be demonstrated by neutralization tests with the mouse virus

Another result of the survey was the demonstration of the psychological response of physicians to the educational program initiated by the Surgeon General's Office. It became apparent that epidemic keratoconjunctivitis was a popular diagnosis and was being made in other types of conjunctivitis It was not unusual after a negative test to check back clinically and find definite evidence that the case in point was not epidemic keratoconjunctivitis. It is thus manifestly important to properly place the disease by familiarity with the clinical syndrome. If this is done, spread of the disease may be prevented and we may find that epidemic keratoconjunctivitis is not one of the more contagious diseases Another result of this survey suggests that the country-wide epidemics were due to the same strain of virus since convalescent serum from Massachusetts, New York, District of Columbia, Texas, Louisiana, Michigan and California neutralized the New York strain of virus.

Preliminary studies with the virus experimentally isolated indicate that the agent persists in and may be recovered from solutions commonly used in clinics where patients with foreign bodies in their eyes or with conjunctivitis are treated. These solutions include fluorescein, novacain, zinc sulphate, boric acid, mineral oil adrenalin hydrochloride and atropine sulphate.

From the foregoing considerations, it should be apparent that general preventive measures against the spread of epidemic keratoconjunctivitis include education of patients, contacts and physicians This appears to be borne out by the results which have attended the efforts of enlightened public health authorities particularly in New York, Massachusetts, Maryland, Illinois and Michigan Since the medical profession has become aware of the problem of epidemic keratoconjunctivitis no epidemic has been reported, although the disease is undoubtedly present in several areas where important industries are concentrated.

So far as treatment is concerned, the principal mainstay has been conservative measures of routine ophthalmological procedures for symptomatic relief. While there have been reports of success with the sulfonamides, this group of drugs given orally and applied locally has been of no avail—a finding which has been confirmed by entirely negative results obtained in the laboratory when the drugs were tested against the experimentally isolated virus. While some hopeful results were obtained with convalescent serum in a small group of patients,[7] a note of caution here, as in all therapeutic procedures, is indicated As was noted earlier, there is a great variability in the course of individual cases and it is certainly not difficult to make fallacious observations concerning the efficacy of therapeutic agents, unless the observations cover many cases under controlled conditions.

MURRAY SANDERS

[7] A. Braley, M. Sanders, *J. A. M. A.*, March, 1943, vol. 121.

THE PORTABLE PIPE LINE

MODERN "blitz" warfare based on the machine is crucially dependent upon petroleum transportation At the outbreak of the war in 1939 the sheer weight of petroleum products in bulk represented an appalling problem and the exposure of oil-carrying trucks to air attack was another. As a result of research in these problems the portable pipe line was designed and put into effect The designer was Sydney S Smith of the Shell Oil Company Inc. which authorized an appropriation of $10,000 for experimentation in the Middle West

The pipe line seemed to be the answer to the difficulties, such as hazards of bombing and poor surfacing, that were being presented by the Burma Road. A plan was drawn up which included some of the following features: twenty-foot sections of flexible pipe to follow the contours of the countryside, thus doing away with the necessity of digging trenches; pumping stations located at twenty-mile intervals; transportation of all equipment—pipes, couplings, pumps, etc—by truck, trailer or mule; automatic stoppage of the flow at any point

PLACING A TWENTY-FOOT SECTION OF THE PORTABLE PIPE LINE

REGULATOR SECTION

along the line; automatic pressure controls to prevent trouble in case of a break

The plan was accepted by the Chinese Defense Supplies Corporation interests and application was made to Lend-Lease for the required steel Much of the pipe had been accumulated for transportation when the United States Army authorities decided that the portable pipe line was important for United States operations abroad A survey had been made to determine the possibilities of installing a pipe line on the Burma Road, but when the Road was lost the 1,000 miles of pipe ordered for China was diverted to North Africa.

Tests were made by the Army in the Shenandoah Valley, Virginia. During the tests a flood washed out a bridge over which a portable line had been slung The strength of the pipe was indicated by the fact that the bridge remained suspended on the pipe line alone and the connection was not broken The only alteration in the original plan suggested by the Army was the reduction in size of the pumps to provide easier transportation. The result is that smaller pumps were located at ten- instead of twenty-mile intervals

At least four portable pipe lines were used in North Africa during the recent campaign. They varied in length from 75 to more than 300 miles and they transported gasoline and water in separate lines. The rapid advance of the Allied Forces in Sicily was possible only because petroleum products, through the use of portable pipe lines, were able to follow the advance

The line, having a capacity of 6,000 barrels (252,000 gallons) a day, is 4 and 6 inches in diameter It can be laid at the rate of ten to thirty miles a day by unskilled or regular Army personnel and can be operated under the supervision of a few trained operators The cost of material (not including transportation or labor) is about $3,000 a mile

No communication system is necessary because of the automatic cut-off and because only one kind of product is shipped through each line so as to avoid dispatching complications under battle-front conditions

The light weight flexible pipe is made in twenty-foot sections, and each section weighing only ninety pounds, can be readily lifted and carried by one man The pipe is spiral welded and the ends are grooved for Victaulic couplings The total weight a mile, including pumping stations, is approximately thirteen tons As the line is laid, gasoline can follow along immediately through the pipe. Maximum rate of filling the line is about 2 5 miles an hour.

Gasoline-fueled engines operate the pumps; they were originally mounted on rubber-tired trailers for quick and easy movement but, in order to save gasoline and rubber, the Army ruled that they were to be placed on skids instead. Being flexible, the pipe line is not nearly as vulnerable to bombing as a rigid pipe line Also, damage caused by bombing, sabotage or other mishaps can be rectified quickly. An individual pumping station, if put out of action, can be replaced in a few hours. During the interval the capacity of the lines is reduced only about thirty per cent. and returns to normal immediately upon the installation of the new unit.

H. Wilson Lloyd

FIELD MUSEUM—FIFTY YEARS OF PROGRESS

On September 16 Field Museum of Natural History, in Chicago, celebrated the fiftieth anniversary of its founding by the late Marshall Field I Within the short span of its existence Field Museum has, through the generosity of individuals, the foresight of its directors and the brilliant work of its staff scientists, become one of the world's four leading museums of natural history The Museum was established as an institution to provide means for popular education along scientific lines and was dedicated to four great sciences—anthropology, botany, geology and zoology For the fifty years since it grew out of the inspiration engendered by the success of Chicago's Columbian Exposition it has continued to broaden its scope and methods to include many important expeditions to all parts of the world, technical research, and education with special emphasis on attractive and instructive methods of museum display

In half a century the Museum has sent out 440 expeditions, published 566 major scientific works, plus numerous handbooks, guides and popular leaflets Its reference library has grown to include approximately 130,000 books and pamphlets, and its study collections, built on the research findings of its scientists, have become an important source for scientists all over the world In the field of education, the Museum has made tremendous technological advances, it has worked with radio and pioneered in television programs and looked into the future when the museum will be brought into the home and the results of science

FIELD MUSEUM OF NATURAL HISTORY, CHICAGO

HABITAT GROUP OF QUETZAL FROM GUATEMALA

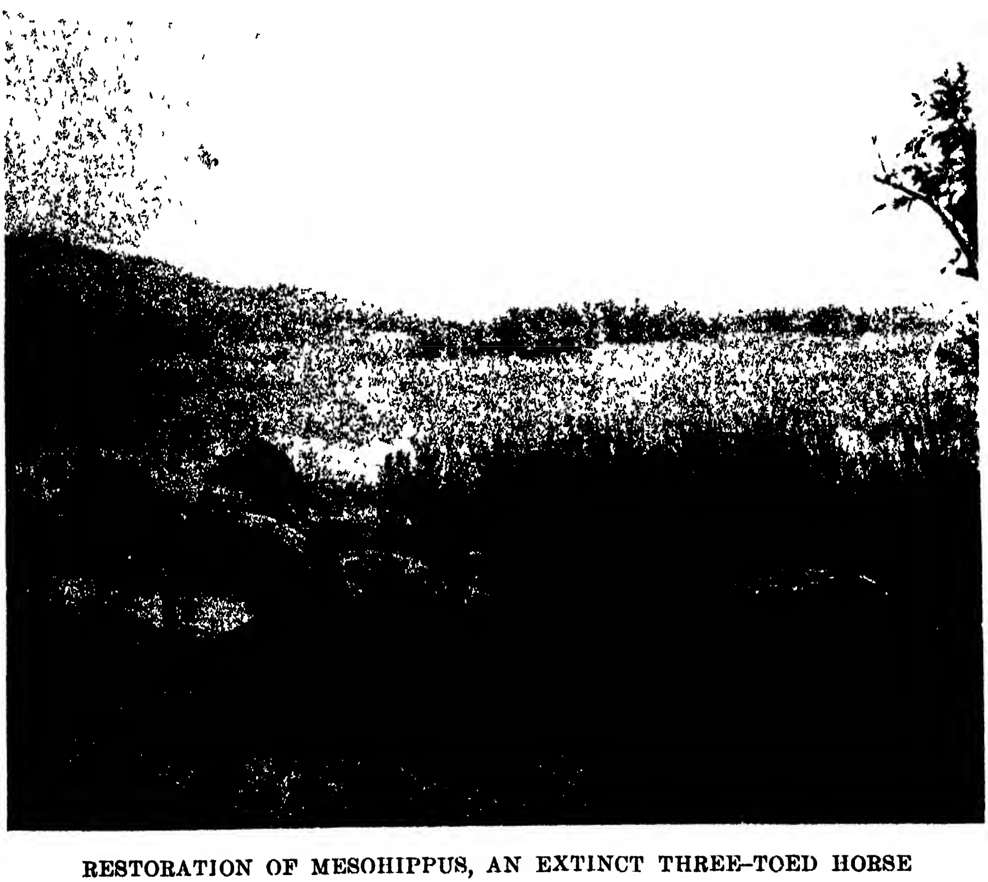
made common knowledge to the people for the benefit of their welfare and good citizenship. The outworn conception of the museum as a repository has been replaced by a vision of it as an up-to-date educator of the public

Field Museum was one of the first to install habitat groups in natural settings. Much of the material and data used for these exhibits of the plant, animal and mineral kingdoms was collected by the staff on expeditions in North and South America, Africa and Asia. Every effort was made to create displays that are both striking and self-explanatory through the introduction of effective artificial

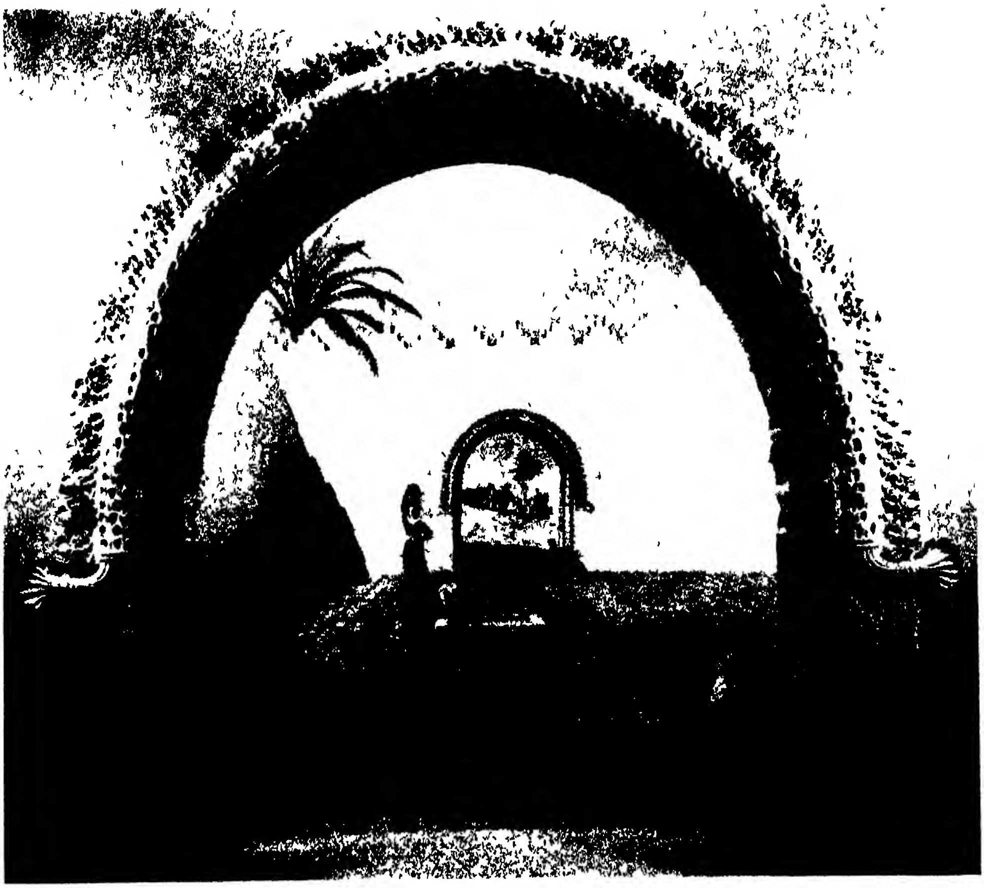
lighting, labels, drawings, maps and photographs. As a result, the thirty-three million who have visited the halls of the Museum have had the privilege of learning through enjoyment. Modern museum techniques are particularly well demonstrated in the new Hall of the Archeology of North, Central and South America, the completion of which has been interrupted by the war.

Members of the Museum's staff are making valuable contributions to the war effort. Their knowledge gained through expeditions and research is being used with important effect, especially with relation to geography of remote spots, such as the Solomon Islands or the Galapagos, that, for wartime, have become vital to our national security. Botanists are giving information about poisonous and edible plants of the tropics, geologists about the Arctic, zoologists about snakebite in South America and Africa, and entomologists about insect-borne disease The vast sphere of the museum, far more important than is generally known, is suggested in the following words by Stanley Field who has been the Museum's president for the past thirty-five years: "Field Museum is a microcosm of the basic realities of this world Embraced within the scope of the four great natural sciences to which it is devoted are the fundamental elements of everything in life, and the causative factors that make people and other living things what they are"

In "Fifty Years of Progress," a special, golden anniversary issue of *Field Museum News*, staff members of the Mu-



RESTORATION OF MESOHIPPUS, AN EXTINCT THREE-TOED HORSE



RESTORATION OF SASANID PORTAL FROM ANCIENT CITY OF KISH

seum summarize the Museum's history and forecast its future Stanley Field writes

From the evidence before us today, it seems safe to predict that there will be two main trends in the future development of this and other great museums. First, with new conceptions of what constitutes true liberal education and what is necessary to adjust individuals to occupy their proper places as citizens of an international community which must be reorganized on lines of peace, humanity, and justice in all nations, museums may be expected to play an ever larger and more active educational role. Second, with the technological advances which were already apparent before the war, we may expect peacetime applications in the field of museology, as in all other fields, which will greatly increase the usefulness of museums .

The way to the kind of world understanding which we all realize is needed -an international understanding that will make for peace and justice and fairness between individuals and between nations—is through an understanding of the forces of nature, a comprehension of the distribution of natural resources, a knowledge of plants and animals, and, most important, an unprejudiced and undistorted view of the character of other peoples, and of the effects of environment upon peoples

M. D

BOOKS ON SCIENCE

CANCER EDUCATION*

THIS is a very interestingly written book about our modern knowledge of cancer, but the reviewer did not have to read very far before receiving the distinct impression that the author was unable to critically evaluate the source material which he consulted in its preparation. The claims of numerous investigators long discredited or never confirmed have been given equal emphasis with well established facts This is bound to result in confusing rather than clarifying the mind of the lay public concerning just what we really do know today about cancer. In the chapter on "Food and Cancer" so many conflicting so-called "authorities" have been quoted that the author in the last paragraph realizes that, "by this time the reader is doubtless thoroughly confused on the question of diet in relation to cancer" Then, leaning too far in the opposite direction, he says, "As a matter of fact it is felt by real cancer experts that diet has nothing to do with cancer" Only a very rash "cancer expert" would make this statement.

Although the publisher advises the reader to "Protect yourself by a careful reading of this authoritative book," it is believed that few if any cancer investigators would ascribe to the following quotations:

> "The diagnosis of cancer in its earliest possible stages is one of the great accomplishments of the modern cancer fighter"
>
> "One of the most interesting facts that has come to light is that cancer develops more slowly in well nourished and active individuals than in those who are anemic and in poor health"
>
> "Cancer of the stomach in its earliest stages can be detected by all surgeons"
>
> "It has been found that the essential differences between a normal and a cancer cell is a qualitative, not a quantitative one, which means that they are different in kind, rather than in quantity."

The activities of the American Society for the Control of Cancer and the various state cancer control programs in the field of cancer health education are not included in *The War on Cancer*

R. R SPENCER

* *The War on Cancer.* Dr. Edward Podolsky. 179 pp. 1943. $1.75. Reinhold Publishing Corporation.

HAND PSYCHOLOGY[1]

STUDENTS of human biology have gradually reached the realization that morphological, physiological and even psychological variations tend to occur in more or less definite combinations which form a variety of constitutional types This fairly well established conclusion had, in a sense, been vaguely anticipated by several ancient and pseudo-scientific practices, such as phrenology and palmistry, which claimed to have discovered the mysterious correlations between certain detailed morphological features and intimate traits of personality, besides the past and future of an individual's fate

The psychologist-author of the present book is a modern and sincere apostle of a new version of palmistry, or as it is now called, "hand psychology." In essence she attempts to demonstrate an unexpectedly close correlation between the detailed configuration of the hand and the outstanding traits forming the personality complex of the owner of the hands Where one expects to find a summary of this book there is a final case-history from which the author concludes that the precise variations in the crease-lines of the palm are not only of diagnostic, but even of prognostic value for the correct interpretation of a person's emotional and mental peculiarities To quote some of the author's novel claims. "From the *form* of the hand we may expect to derive a general impression of (1) physical constitution and heredity; (2) emotional and instinctual potential

[1] *The Human Hand.* Charlotte Wolff. xvii + 198 pp. $3.00. May, 1943. Alfred A Knopf.

—in short, temperament; (3) mentality and innate gifts and talents. From the *nails* and the hand's *physical qualities* we can find indications of heredity and health conditions From the *parts* of the hand we should be able to decide: (1) the relative strength of *ego* and *id;* (2) the force of the will; (3) a more detailed conception than the study of the form of the hand alone elicits of the 'active' and 'receptive' aspects of personality." The *lines* in the palm, finally, are claimed to reveal "the strength or weakness of the super-ego" and give an idea of "the mental and emotional discipline," and various other conditions difficult to detect.

In spite of the author's scientific terminology, measurements, anatomical and medical discussions, and many plates of palm prints, her treatise remains unconvincing, to say the least It is, however, a welcome reminder that we might expect eventually to find and prove a closer tie between morphological and psychological personality traits than is commonly believed to exist

That Dr. Wolff shows more courage than care in arriving at her conclusions, is evident from the following startling and incredible claim: "I discovered that in respect of the length of the terminal phalanges only the brown capuchin monkey bears any close resemblance to man. This and other features which I observed seem to confirm the evolution of man not from the anthropoids but from a primary stock of New World monkeys which was the common ancestor of both "

In the preface by Dr W. Stevenson it is stated that Dr. Wolff has made "a broad sweep over a new field of psychology" and that "this new branch of study . . . is ready for the polish of scientific elaboration later on." That polish is unquestionably needed and will have to be quite penetrating.

ADOLPH H SCHULTZ

THE STORY OF SULFUR*

AT less than one cent a pound sulfur is by far the cheapest chemical element. At 99.5 per cent purity it is the cleanest of raw chemicals With over three million tons on hand it is one of our greatest war assets. The United States consumes more than thirty pounds each year for every man, woman and child, a total of two million tons. This is twice our usage of copper, three times that of rubber, five times that of tobacco. A knowledge of what sulfur means should be as commonplace in America as the knowledge of automobiles or of Yellowstone Park.

That knowledge has been available in every elementary textbook in chemistry. Now Mr. Williams Haynes, long-time editor of *Chemical Industries* and chemistry's ablest interpreter to the public, has made the entire story available in a book that is more fascinating than a novel, far more comprehensive than any textbook. The most fascinating part of the story is, of course, that of Herman Frasch and the development of his hot water process for bringing sulfur to the surface Mr. Haynes has studied the record of the early nineties and unfolds the adventures and achievements of Herman Frasch as an American epic

But "The Stone That Burns" is also a record of subsequent developments and of the present status of the industry The appendix contains twenty statistical tables including such items as world sulfur production, sulfur content of foods, United States and world production of pyrites, and United States production of sulfuric acid The book does not contain any discussion of the chemical industries based on sulfur, such as the manufacture of sulfuric acid.

GERALD WENDT

* *The Stone That Burns. The Story of the American Sulphur Industry.* Williams Haynes. Ill. xii + 345 pp. $3.75. August, 1942. D. Van Nostrand Company, Inc.

EXERCISES FOR SUPERMAN*

Now is the time for all good athletic directors to come to the aid of their cause The urgent need for husky youths to man the guns and tote the loads of war justifies the present reopened clamor and ballyho for bigger and better muscles. Brawn and endurance are vital despite mechanization Competitive college athletics are blacked out for the time being; if not wholly blacked out, at least as effectively as most communities are in their practice drills There is a bigger, finer and more precious Alma Mater now. our Nation and our way of life It is really win or die—no longer a mere game

Thus a new book describing calisthenic exercises by a professor of physical education could be called both timely and apparently constructive John Kiernan's typically brilliant and blessedly brief foreword is convincing even to the skeptic: there can be no question but that the author of the text is a great swimming coach and knows how to develop speed in Yale swimmers But Mr. Kiernan's suggestion that the shocking number of rejections of young men called up under the Selective Service Act could have been materially reduced by even the most fanatic and devout attention to daily exercises is decidedly misleading Statistics from the Selective Service itself reveal that the major reasons for rejections have been: Dental defects, visual defects, circulatory defects, including all forms of organic heart disease and disturbances of the blood pressure; nervous and mental disorders and musculo-skeletal defects or diseases, including amputations, congenital skeletal abnormalities and joint diseases. The frequency of none of these reasons for rejection, with the possible exception of a very few of the musculo-skeletal defects, is amenable to diminution through the medium of calisthenics, no matter how well planned, clearly directed and conscientiously carried out. The reviewer's own experience in the sad, perspiring grind of examining selectees for physical fitness has led him to feel that more lads are rejected because of overstrenuous athletic activity in adolescence than because of any lack of big bulging muscles

It is furthermore significant that the Army physical training program has revealed that farm boys and white collar clerks develop endurance for the long grueling grind of military maneuvers quicker and to a higher degree than most high school and collegiate athletes. This is a sad blow to athletic coaches who have never appreciated the long-term meaning of the difference between speed in "sprints" and ability to endure less violent exertion for a longer time. American impatience and the cheers of childish alumni have given "sprint sports," whether on the field, on the track or in the pool, a wholly unwarranted prominence. Far better background for endurance is the steady plodding behind the plow or the dusty, scratching, sweaty job of stacking hay in the loft Less "glorious," but far more constructive.

That calisthenics are of value in building muscles, developing better posture and assisting in the maintenance of health is not denied. It is their relative worth, in contrast to other factors in constructing health, which is open to question. The chief objection to the present book is the misleading nature of it's title· "How to be Fit." There is far more to fitness than bone and muscle. Included are such factors as mental ability; capacity to learn, to correlate and to judge; emotional stability; liberal functional reserve capacities of all the vital organs of the body and an implied promise of continued high per-

* *How to be Fit.* Robert Kiphuth Foreword by John Kiernan. 131 pp. $2.00. 1942. Yale University Press.

formance in many activities. In other words, there are many kinds of fitness and many kinds of jobs to be done to win this war and to maintain a lasting peace.

The text of the volume consists of detailed, precise instructions for fifteen basic lessons, each with eight exercises and then an additional group of more strenuous exercises designed for young men working in groups or classes. Each exercise is clearly illustrated by superb photographs. The instructions are ample. All that remains necessary then, is the desire to posture, squirm, flex and stretch. One wonders how many readers will have the fortitude to continue through all these lessons without the lash of ambition for glory in sport or the harsh bark of the sergeant at drill. All the branches of the Armed Services have their own manuals of calisthenic drill and their own enthusiastic physical directors We must not forget that equally effective as muscle and posture builders are exertions which entail pleasure and emotional relaxation or, better yet, accomplish some useful work in the doing. The book, though very well done, hardly seems necessary

EDWARD J. STIEGLITZ

THE PSYCHIATRIC WORLD*

THE present volume is the second edition, thoroughly revised, of a book which first appeared only two years ago

* *The Therapy of the Neuroses and Psychoses* Samuel Henry Kraines, M.D. 2nd edition 567 pp. 1943 $5 50. Lea & Febiger

That fact by itself is indicative of the progress in psychiatric therapy and of the author's clarity of presentation.

Much has been written of what may be termed psychiatric theory, of the dynamics and mechanisms of mental disorder, and there are available many descriptions of the symptomatology of mental disease So true is this that the general public is sometimes prone to think of psychiatry in descriptive terms and not as what it really is—a specialty of medicine, and as such interested primarily in treatment and prevention.

Relatively few books devoted to psychiatric treatment have appeared, and Doctor Kraines' contribution serves a real need The first fourteen chapters deal largely with the psychoneuroses; this is proper, for that group constitutes a large majority of the psychiatric disorders, common though the psychoses (the major mental disorders) are Then follow chapters on the psychoses and other psychopathic states, on neuropsychiatric states in wartime, and on shock therapies The general orientation is "psychobiological," which results in a rather light touch for anything savoring of the Freudian

The therapeutic approach is conservative, but the tone is justifiably optimistic, and the advice given is sound. Although this book is written primarily for the medical student and practitioner, the interested layman will gain a wider horizon of the psychiatric world from its perusal

WINFRED OVERHOLSER

THE SCIENTIFIC MONTHLY

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CAN HORMONES HELP WIN THE PEACE?

By Dr. ERWIN P. VOLLMER

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"WINNING the peace" is a big order, political and social in nature, and the possibility that hormones may have a place in it will seem an exceedingly remote one to many. Particularly will it appear so to the layman, who regards the endocrine glands as a bit of the medical profession's academic property.

But one of the ramifications of winning the peace is the activity of rehabilitation. The purpose of this activity is the rebuilding of cities, and more important, the restoration of the health of the people who are to inhabit them. These people will have lived for a long time under conditions of terrible privation. Few, if any of them, will have escaped periodic or sustained hunger, and most of them, particularly the children, will be suffering from malnutrition varying in degree and kind. If at this point the question were asked whether vitamins could help win the peace, even poorly informed people would answer affirmatively. All who can read the advertisements know of the existence of vitamins, and of their importance in nutritional well-being.

I

From a theoretical point of view, most of us have a rather one-sided idea as to what constitutes nutrition. By a long process of education we have come to think of it in terms mainly of the substances which we must obtain and place at the disposal of our digestive tracts; that is, the essential foodstuffs. In a practical sense this emphasis upon the *extrinsic* phase of nutrition is justified. An individual can apply his knowledge of it directly, in ordering from a menu or in buying food for his family. But when the food has been received by the digestive tract, the processes of nutrition have only begun. The breakdown substances, which are our real food, must be shifted about in the body, altered, and reshifted until they reach the cells which are finally to use them. In his outstanding book on malnutrition, published in 1925, C. M. Jackson referred to these complex internal dealings as *intrinsic nutrition.*[1] And the basic influences controlling this part of nutrition, according to the same author, are heredity, toxins, *and the hormones.*

In the eighteen years since the two phases of nutrition were thus defined, an extensive new content has been put into the concept, especially in so far as the hormones are involved. This is because the larger part of our knowledge of the endocrines has been established in these years, *and to a surprising extent this knowledge is concerned with what happens to food substances once they have entered our bloodstreams.*

Let us consider, by way of example, what may happen to a single foodstuff. Some carbohydrates, when completely digested, give rise to the simple sugar

[1] C. M. Jackson, *Inanition and Malnutrition.* P. Blakiston & Co., Philadelphia.

glucose, which is the ideal fuel of our cells. After the glucose has entered the blood, it is picked up by the liver cells and stored away, to be released into the blood gradually during the intermeal period. If one has a diseased pancreas and therefore is deficient in *insulin*, this storage does not occur; much of the glucose is washed away in the urine, and the body cells have to use other substances as fuel. New shortages are thus created, and the diabetic victim wastes away. The cells do not stop burning fuel on account of the glucose shortage; they merely switch to other fuels and tend to continue metabolizing at the previous rate. This rate, in turn, is governed to some extent by several endocrine glands, especially the thyroid. If one's thyroid is too active the sugar is burned too fast, and again there is a supply problem. Again the cells are forced to use proteins for fuel, and emaciation may result. On the other hand, if one's thyroid is underactive, the sugar burns too slowly; there is a glut of sugar which is usually converted into fat. This is the cause of one type of obesity. Another gland which is concerned with the use of glucose is the adrenal If the adrenal cortex is underfunctioning there will be too little glucose in the blood. If the adrenal medulla is defective, the blood cannot receive the little bursts of glucose from the liver which presumably help one to withstand sudden stress. Finally, if one's pituitary is functioning badly, the sugar is mishandled in other ways, depending on the nature of the disorder. *Thus, the distribution and use of glucose within the body are controlled by at least five endocrine glands.* Other food substances are probably subject to similar influences

Similary, gross structures of the body, such as bone, are affected in growth and differentiation by individual and synergistic action of hormones. This being so, it is clear why disorders of the anterior pituitary can bring about such drastic changes in an individual. This organ secretes a miscellany of hormones: one which keeps the adrenal cortex in normal size and function (*corticotropin*); one which stimulates the thyroid (*thyrotropin*); several which maintain the sex glands (*gonadotropins*); and some others, which, like the growth hormone *somatotropin*, produce general effects. Slight periodic shifts in the relative output of these hormones, in normal animals, bring about sequential events such as menstruation, mating seasons, and migrations. Pathological changes in the pituitary cause profounder shifts, which may produce dwarfs or giants, human skeletons or human gorillas. All such phenomena represent changes in intrinsic nutrition, of which bodily size, shape, and (in the narrow sense) behavior are only the outward expression.

Upon the basis of such indications it might be thought feasible to try hormones empirically, as drugs often are tried, to improve the nutritive processes of starvation victims. But the hormones are powerful drugs, and their use may involve dangers, especially in organisms whose metabolic activities have become abnormal It would be better to try first to answer the following questions: *first, whether chronic malnutrition has lasting effects upon organisms; second, whether these effects may be due in part to endocrine injury; and third, whether hormone therapy gives any promise of repairing the injury or of sustaining the organism until spontaneous recovery can occur.*

II

For five months of the 1914–1918 War, fourteen thousand British Empire soldiers were besieged by the Turks at Kut, Mesopotamia. During the siege their rations were only one-third to one-half of the normal quantity. Death from starvation was common, and every man

was severely emaciated when the siege ended. The medical end of the grim story was related several years afterward by Major-General Sir Patrick Hehir. After noting that the return to normal diet must be very gradual (a full meal sometimes being fatal) he wrote:

> It was a long time before those who went through the siege . . . regained normal weight; in my own case it was one and a half years. This appears to be the record of all long sieges. . . . The digestive glands of the stomach, the pancreas, and liver, have undergone considerable atrophy, and are long in recovering their normal functioning activity It was about two years before I personally could consume a normal meal as regards quantity . [2]

This passage is quoted to emphasize the deep-seated effects of starvation, and the long time required for recovery. If strong men, starved for five months, take two years to recover, how long will it take the children of China and Europe who have starved for three to five years?

As a matter of fact, very little is known about the effects of chronic malnutrition in human beings, particularly during and after the resumption of feeding Genetic differences in size and constitution are so great that an honest physician would hesitate, several years after famine, to ascribe the short stature of one individual or the illness of another, to malnutrition in the past In summarizing the available clinical and experimental evidence, Jackson comments, "Between these upper and lower limits of inanition [weakness from starvation], there is probably in all cases a degree of injury possible which permits only of partial recovery, resulting in a variable degree of dwarfing . . . of the body " This has been borne out abundantly by experiments with animals. In rats, which have strong powers of recuperation from malnutrition, a diet deficient only in calories may result in permanent dwarfing. Such animals have been described as having humped backs and bulging eyes; such abnormalities of proportion are corrected by normal diet but full size will not be attained. It has been observed that when five-week-old rats are deprived of minerals or calories, an irreversible stunting sets in three to six weeks later—a time roughly equivalent to human childhood. If refeeding is instituted before this effect sets in, the resumed growth is abnormally rapid. Such overcompensated growth might easily be due to unbalanced pituitary action.

One feature frequently observed in undernourished young animals is an irregular, or as Jackson calls it, "dystrophic" growth:

> As already stated, the age at the time of inanition is an important factor, there being critical periods at which various organs are most susceptible . . During the developmental period . . . inanition (especially of the chronic type) frequently results not merely in a retardation or cessation of growth, but in an abnormal, disproportional growth. . . . Some parts may show persistent growth at the expense of others, even during total inanition with continued loss of weight.

For example, underfed young rats have abnormally long crania. Puppies and young steers which have been kept from growing by partial starvation become too tall and long for their body weight. One author comments, "little can be done to prevent the persistent growth of bones. . . . In spite of stationary body weight, the physique of the experimental animal slowly changes, the length and height of the body increasing and the thoracic cavity becoming deeper and narrower."[3] Whether these effects, like stunting, are permanent, and whether they appear in human beings, we simply do not know. But we are told, with reference to the Jews of Poland a generation ago: "Their physical strength, their muscular power has diminished in each generation; their

[2] Sir Patrick Hehir, "Effects of Chronic Starvation during the Siege of Kut," *British Medical Journal*. 1922, 1: 865–868.

[3] Arthur H. Smith, "Phenomena of Retarded Growth," *Journal of Nutrition*. 1931, 4: 427–441.

blood is poor; their stature is small, shoulders and chest narrow."[4] Perhaps there is a physiognomy which hunger stamps upon its victims; if so, it is caused by disproportionate growth, a subject which always interests the endocrinologist.

As for the question whether malnutrition affects the endocrine system, the evidence seems fairly definite, although it is not known how long the effects remain. Again going back to the last war, we find this testimony from a young British doctor who spent a long time in an enemy prison camp:

> Many batches of prisoners had been systematically underfed, and had been worked until they were physically prostrated. From each batch some members died a very short time after admission. I was greatly impressed, in carrying out autopsies on these emaciated cases, by the size of the adrenal glands. In a series of eight cases of death from underfeeding the adrenals were enlarged, almost half as large again as normal, and the enlargement seemed, from naked eye appearance, to be mostly in the cortex.[5]

The enlargement of the adrenal cortex in crises is now a well-known phenomenon, due either to adrenal damage or to its stimulation by increased *corticotropin* from the pituitary. H. Selye[6] regards it as part of a "general adaptation syndrome" in which the pituitary is upset by threatening environmental conditions in such a way that more corticotropin is secreted, while less of the gonadotropins, which stimulate the sex glands, are put out. He cites the fact that many German women who lacked food during the last war were incapable of menstruation, a sexual function under indirect pituitary control. Adrenal cortical enlargement in acute starvation has tended to obscure the fact that in chronic—moderate and prolonged—malnutrition, the adrenal cortex becomes atrophied. This is true also of the sex glands, the thyroid, and the pituitary itself, as has been shown by autopsies of men as well as of laboratory animals. *Atrophy, or wasting away, of the endocrine glands is a common feature of starvation.*

This has been proved by physiological experiments, especially with regard to the anterior pituitary. Earlier in this paper "human skeletons" were mentioned. In such persons the pituitary gland for unknown causes has withered away, bringing the condition known as "Simmonds' disease." There is an almost indistinguishable disease (*anorexia nervosa*) which seems to be caused by the victim's inability or unwillingness to eat properly. Autopsy in several cases has shown the pituitary to be atrophied. Laboratory animals with characteristics similar to those of "human skeletons" can be produced by removing their pituitaries. This operation is called *hypophysectomy.* In such animals we know that the emaciation, the weakness, the infantile characteristics, and the atrophy of adrenal, thyroid and sex glands, are all due to the loss of the pituitary gland. But in starved human beings we do not know to what extent similar symptoms are due to direct tissue starvation and to what extent to the curtailment of pituitary activity. At any rate, the effects of pituitary removal and those of chronic starvation are so much alike in experimental animals that Mulinos and Pomerantz[7] have spoken of a *"pseudo-hypophysectomy syndrome."* This scientific mouthful means, "the

[4] Sergius Morgulis, "Fast and Famine," *Scientific Monthly* 1923, xvi: 54–65.

[5] Charles H. C Byrne, "Enlargement of the Adrenal in Starvation," *British Medical Journal.* 1919, 2· 135.

[6] Hans Selye, "Effect of Adaptation to Various Damaging Agents on the Female Organs of the Rat," *Endocrinology.* 1939, 25: 615–624.

[7] Michael G. Mulinos, and Leo Pomerantz, "Pseudo-hypophysectomy," *Journal of Nutrition.* 1940, 19: 493–504. *Ibid.,* "The Reproductive Organs in Malnutrition," *Endocrinology.* 1941, 29: 267–275. *Ibid.,* "Hormonal Influences on the Weight of the Adrenal in Inanition," *American Journal of Physiology.* 1941, 132: 368–374.

combination of symptoms (in starved animals) which simulates the set of effects occurring in animals whose pituitaries have been removed."

The symptoms referred to include such things as the loss of the estrus cycle in female mammals. This loss indicates a deficiency in the animals' sex glands, and the latter in fact are found to be atrophied in underfed rats, guinea pigs, and chicks. In some of the experimental animals, injections of the proper sex hormones cause a regrowth of the sex organs, while gonadotropins bring repair to both sex glands and organs. Fertility is sometimes restored. *It is now fairly certain that the wasting away of some of the endocrine glands during malnutrition is due less to the direct starvation of their tissues than to the failure of the pituitary to support them with its "tropic" hormones.* Hence the results of pituitary removal and starvation are similar because the latter, in effect, removes part of the pituitary That the same may be true in some human cases is shown in the conclusion of one medical authority, that "many of the clinical manifestations of *anorexia nervosa* and other types of chronic manition are due to the effects of undernutrition of the anterior hypophysis."[8]

The third question, whether hormone therapy gives any promise of repairing the damage from malnutrition, has been partially answered by implication in the foregoing paragraph. Even though the male rat continues to be underfed, its genitalia are repaired by gonadotropin or testis hormone. When extra pituitary glands are transplanted into underfed female rats, the estrus cycle and the adrenal cortex are restored, despite continued underfeeding. This, however, is the highwater mark of experimentation along these lines. No one has investigated the resumption of growth in re-fed animals during hormone therapy, in comparison with the growth of animals merely re-fed. No one has tried hormone therapy upon animals "permanently dwarfed" by malnutrition. With regard to the problem of human malnutrition there is little point to hormone therapy experiments *without simultaneous re-feeding.* We need to know, particularly, the effects of hormones with growth, differentiating, protein-saving and bone-metabolizing properties upon animals which have first been starved and then put upon a full and adequate ration.

Even here, however, there are some oblique indications of the possibilities Several kinds of dwarfism have been treated successfully with pituitary and sex hormones Physically retarded children have been induced to grow better, through the administration of gonadotropic and sex hormones. An interesting case[9] may be cited. An infantile, emaciated eighteen-year-old boy, who had not grown for eight years, was treated with anterior pituitary extract In four and a half months he became sexually mature and grew two inches taller (during this time his normal sixteen-year-old brother, serving as a sort of control, had not grown measurably). After treatment he continued to grow and gain weight. It may be postulated that in these successfully treated victims of arrested growth, intrinsic nutrition had been deranged by unknown, perhaps genetic, causes. Since hormone therapy was effective, it may be postulated further that some of the intermediate causes were endocrine in nature. And if hormones can work in such stubborn material, we should not overlook the possibility that they might also be effective in organisms whose intrinsic nutrition has been altered (*via* endocrine impairment) by poor diet.

[8] D. J. Stephens, "Anorexia Nervosa Endocrine Factors in Undernutrition," *Journal of Clinical Endocrinology.* 1941, 1: 257.

[9] Max M. Goldberg, "The Treatment of Pituitary Infantilism with Anterior Pituitary Extract," *Endocrinology.* 1936, 20: 854–855.

III

To refer back to our three questions, it should be noted that they have been answered affirmatively, not in a scientifically conclusive way, but with bits of suggestive evidence. But the evidence holds together and forms a chain of which the chief links are facts well accepted in the fields drawn upon. It is believed, furthermore, to indicate the possible existence of a new opportunity to serve a portion of humanity which most needs help. What, then, can be done to uncover and develop this opportunity?

First of all, we can learn a great deal from animal experimentation. The basic procedures and techniques have been developed The planning of the experiments involves no unusual difficulties, and their accomplishment requires only the usual careful routine work familiar to nutritionists and endocrinologists. These experiments would tell us whether it would be safe to go ahead, or whether the idea of hormone therapy in malnutrition is, as well it may be, a dangerous mirage.

As to the problem of treating human beings, great difficulties may arise. Whether or not cautious empirical trials would be justified is a question which can be answered only by competent medical authorities There may be regional differences in the types of malnutrition incurred, and hence in the resulting endocrine damage. In a given region, individuals may suffer differently. Effort would have to be made to determine the nature of such regional and individual differences, and treatment would have to vary accordingly.

If this sounds like a formidable program, it must be emphasized that malnutrition is not a transient problem. In its severe form, it may be of concern to us for a decade. We may, unfortunately, have more time than we would otherwise desire to have, to solve the questions raised.

A generation ago, at the time of another war, our knowledge of vitamins was even more rudimentary than is our present knowledge of endocrine physiology. To harassed post-war Russia the American Relief Administration sent, among other supplies, only one vitamin preparation[10] During and after the present war we shall send the world's starving peoples many kinds of food and vitamins, carefully evaluated for their potency in restoring human beings to good health Whether or not hormones will also be sent, no one can say. The study of their effects in starved organisms will some day be undertaken in the course of normal scientific activity. But why should we not accelerate this program, as we have so many others?

[10] Harold Henry Fisher, *The Famine in Soviet Russia, 1919–1923; The Operations of the American Relief Administration.* Stanford University Press, 1935.

VISUAL ORGANS OF INVERTEBRATE ANIMALS

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FEW organs in the animal body have undergone so remarkable an evolutionary development as the visual organs, which have developed into several types in different groups of animals Although the image-forming eyes of vertebrate animals are all fundamentally alike, the visual organs of invertebrate animals form seven well-defined types: light-sensitive spots in unicellular animals, light-sensitive body surfaces, light-sensitive cells in the body wall, pigment-cup ocelli, arthropod ocelli, simple eyes, and compound eyes.

These different types of visual organs, however, do not represent an orderly evolutionary series. Animals with light-sensitive cells in their body walls occur in all the major phyla of animals above the Protozoa, which suggests that the members of different phyla may have evolved their own particular type or types of visual organ from visual cells of the body wall. Among invertebrate animals there is often little correlation between the degree of specialization of the visual organ and systematic position of the animal that bears it. In certain phyla, as in the Mollusca, there are found many different types of visual organs, ranging from simple visual cells in the body wall to image-forming eyes

For the most part, the visual organs of invertebrate animals are concerned chiefly with the perception of light and hence are often called *photoreceptors* The term *eye* is usually applied only to those visual organs having a light-sensitive layer of cells, the retina, on which light rays from external objects are focused. One must not judge the visual powers of an animal by the structure of its visual organ alone, but must also consider the brain mechanism that is connected with it

The lower invertebrate animals are often limited in their visual functions to the perception of light, but the higher invertebrate animals can often perform as many as six different functions from information which they receive from their visual organs They can detect light (distinguish light from darkness), distinguish between different intensities of light, determine direction of light, determine depth and distance, determine form (image-forming eyes), and distinguish colors (color vision). In general these different functions represent stages in the functional evolution of visual organs, although the mechanisms by which they operate may be quite different in different animals

If the *presence of light* cannot be detected, it is obvious that none of the other above-mentioned functions can exist. If light can be detected, *intensity discrimination* may also occur without additional morphological differences in the visual organs. This is shown by *Amoeba* and by certain other animals in which the surface of the body is sensitive to light.

In order for an animal to be able to determine the *direction of light* it is necessary for certain regions of the body to be more sensitive to light than other regions, or for certain visual cells to be stimulated to the exclusion of others, as in the earthworm, leech, *Planaria* (Figs. 1A, 1B, 1C) and certain other animals. In some animals pigment partly surrounds the visual cells so that light can enter from only one direction, and in

others lenses serve to focus light upon the visual cells, as in the ocelli of insects. Such visual organs enable their possessors to determine the location and movement of objects.

The perception of *distance* usually demands binocular vision, as in man, but the visual organs of certain arthropods and mollusks seem well adapted for this purpose. Since the eye of the scallop, *Pecten* (Fig 4A), has two separate retinas (proximal and distal), it is probable that light rays from a distance and those from nearby are focused on different retinal layers. The situation in certain myriapods (Fig. 2A) is quite similar, since their visual organs have several layers of retinal cells. Human beings can judge distance with one eye, only if they know the size of the object and consequently have some judgment of the angles it would subtend at different distances While binocular vision is usually a prerequisite for judging the distance of objects, it is probable that a few animals without this type of vision can nevertheless judge distances.

The perception of form (image-formation) is possible only if the aperture through which light enters the eye is very small, as in *Nautilus* (Fig. 3B), or if a lens is present and forms an image on the light-sensitive retina. To form clear images of objects at different distances it is necessary for the eye to have the power of accommodation. The clearness of the image also depends on the structure and shape of the lens.

There is evidence that some of the higher invertebrate animals, such as bees and certain other insects, as well as many vertebrate animals, possess the power of color vision. As is well known, visible light is composed of waves of various lengths. Long waves affect certain retinal cells, resulting in the sensation of red; shorter waves stimulate other retinal cells, resulting in the sensation of green, and still shorter waves, blue.

Light Sensitive Body Surfaces

In the simplest animals a specialized light-sensitive structure is not necessary, since the protoplasm of the entire body surface is sensitive to light. When *Amoeba* is exposed to strong light no pseudopodia form on the exposed side. *Amoeba* is equally sensitive to light over its entire body, but many of the more specialized Protozoa are more sensitive to light in certain regions than in others. In such organisms as *Euglena,* for instance, photosensitivity is limited to the eye-spots.

Planaria from which the visual organs have been removed react to light in much the same way as normal animals. Similarly many vertebrate animals, including certain fishes and frogs, which possess visual organs, have been shown to have also a "skin" sensitivity to light. Even though these animals are blinded, they still possess the ability to respond to light. It has been supposed that free nerve endings in the skin serve as receptors. However, recent work on *Dolichoglossus* and *Crangon,* in which light-sensitive cells were found in the outer body wall, suggests that light-sensitive cells rather than free nerve endings may act as receptors in most, if not all, animals having a "skin" sensitivity to light.

Light-Sensitive Cells in Body Wall

The work of numerous investigators shows that most, if not all, metazoan animals having light-sensitive body surfaces have cells in the body wall that are stimulated by light. Such names as photoreceptors, visual cells, retinulae and rod cells have been applied to these sensory structures. For purposes of uniformity we shall refer to them as visual cells.

Visual cells which are more or less unspecialized in structure but which function as photoreceptors are found in the outer body wall of many coelen-

terates, echinoderms, annelids, mollusks and arthropods, as well as in certain vertebrates. Although many of the lower coelenterates, such as *Hydra* and sea anemones, respond to light, visual cells have never been found in their body walls. In certain jellyfishes and many other animals, pigment cells alternate with visual cells. Simple visual organs may be found in the higher, as well as in the lower, animals and simple as well as complex organs may be found in the same animal.

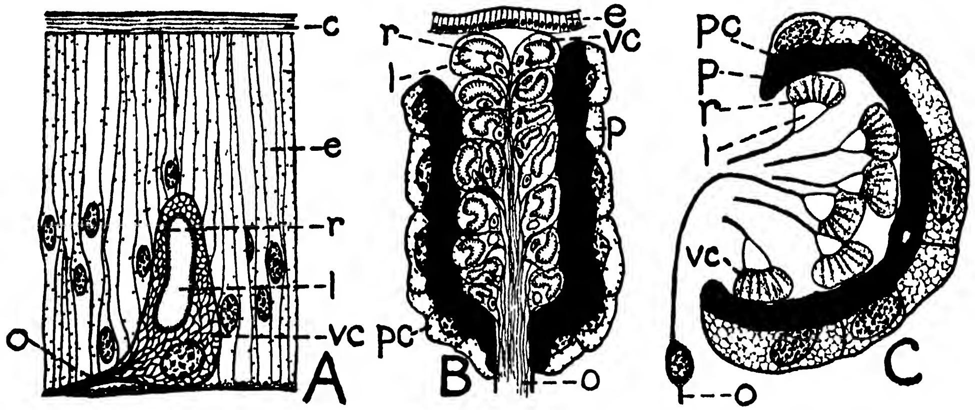

FIG. 1. VISUAL CELL OF BODY WALL AND PIGMENT-CUP OCELLI
(A) VISUAL CELL OF EARTHWORM BODY WALL; (B) PIGMENT-CUP OCELLUS OF LEECH, (C) PIGMENT-CUP OCELLUS OF *Planaria;* (c) CUTICLE OF THE COMMON EARTHWORM, (e) EPITHELIUM, (l) LENS, (o) OPTIC NERVE, (p) PIGMENT, (pc) PIGMENT CELL, (r) RETINELLA, (vc) VISUAL CELL.[1]

Since the visual cells of the common earthworm, *Lumbricus terrestris* (Fig. 1A), are better known than those of most other animals possessing visual cells in the body wall, we will use them as examples of this type of receptor. They are found near the base of the outer body epithelium of all body segments and in nerve enlargements of the prostomium and the caudal segment. However, the largest number is found in those regions that are most photosensitive, especially the prostomium. Each visual cell contains an inner cylindrical lens, which is surrounded by a neurofibrillar network, the retinella. This lens is usually bent so that different portions of it lie in different planes. Consequently, it usually focuses light on portions of the retinella irrespective of the direction from which the light comes. Therefore the neurofibrillae of the retinella appear to be the direct receptors of light stimuli. The long-necked clam, *Mya arenaria,* has similar visual cells located in the walls of its siphons

Many of the polychaete worms, such as *Nereis virens,* also have, in addition to simple eyes, visual cells in the outer body wall which resemble those of the earthworm in structure. In the primitive chordate, *Dolichoglossus kowalevskyi,* visual cells resembling rods and cones in shape are found at the base of the epithelium of the body wall.

Visual cells, such as have just been described, function in the detection of extremely small amounts of light, as well as in detecting differences in intensities. Because of the location of their visual cells, these animals are also able, to some extent, to detect the direction of light. This is shown by the fact that when

[1] Some of the figures used in this paper were redrawn with modifications from the works of earlier authors.

earthworms are experimentally illuminated on one side only they turn away from the light. It was not, however, until pigment-cup ocelli evolved that animals could determine the direction of light with any degree of accuracy, and it was not until simple eyes evolved that animals were able to determine the form of objects.

Pigment-Cup Ocelli

It was in the flatworms that Nature first massed together near the anterior end of the body visual cells of the type that we have just described for the earthworm and partially surrounded them with a cup of cells containing pigment. Thus was formed our third type of visual organ, the pigment-cup ocellus, which is found in many leeches and flatworms and in some of the early chordates, such as *Amphioxus*. While the visual cells within the pigment-cup ocelli of the flatworm, *Planaria maculata*, appear to be superficially different from those of the earthworm and leech, they possess the same intracellular lens and retinella (Fig. 1C). The only essential difference is that the lens and retinella are differently located within the cell.

The size of the openings of pigment-cup ocelli differs considerably in different animals. It appears possible that a perception of light direction is obtained in those animals of the pigment-cup type when the opening to the exterior is very small However, it has been shown that the individual visual cells of the pigment-cup of *Planaria* are stimulated only when their axes are in the direction of the incoming light. This indicates that it is not the pigment-cup but more especially certain structures within the visual cells which enable this animal to detect the direction from which light enters the ocellus.

The pigment-cup ocellus may be formed of the pigment-cup and only one visual cell, as in *Amphioxus* and certain flatworms, or it may contain many visual cells as in leeches and *Planaria* (Fig. 1B, 1C). In the pigment-cup ocellus of *Planaria*, the sensitive region of each visual cell, the retinella, lies between the lens of the cell and the pigment-cup, the farther end of the visual cell being di-

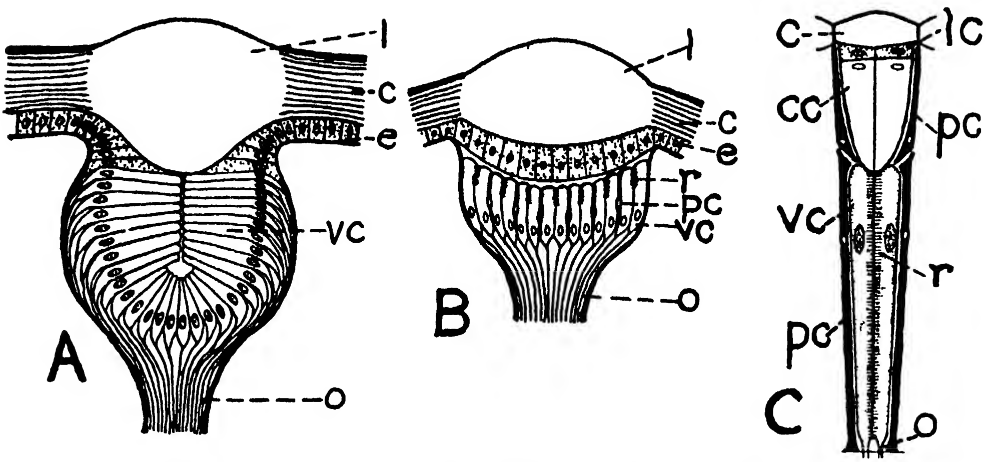

FIG. 2. ARTHROPOD OCELLI AND OMMATIDIUM OF COMPOUND EYE
(A) OCELLUS OF MYRIAPOD (*Heterostoma*); (B) OCELLUS OF INSECT, (C) OMMATIDIUM OF COMPOUND EYE OF INSECT, (c) CUTICLE, (cc) CRYSTALLINE CONE, (lc) LENS-SECRETING CELL, (e) EPITHELIUM, (l) LENS, (o) OPTIC NERVE, (pc) PIGMENT CELL, (r) RHABDOM, (vc) VISUAL CELL.

rected away from the incoming light. These visual cells, therefore, resemble the retinal cells of vertebrates in that they are inverted. Animals possessing visual organs of this type are able to distinguish light and its relative intensity and direction much more accurately than those with the receptors in their body wall. Hence, these visual organs are called *direction eyes*

There is no evidence that any of the more specialized types of visual organs evolved from pigment-cup ocelli Indeed, there is much evidence against such a hypothesis.

Arthropod Ocelli

As we pass from animals with pigment-cup ocelli, we come to others having two quite different types of visual organs, both of which are in the general pattern of miniature camera eyes. One of these types of visual organs has a vesicle which usually contains a vitreous body and a lens (Fig 3C) The visual organs of many echinoderms, annelids and mollusks are of this type and are known as *simple eyes* The other type of visual organ has no vesicle, and the thickened cuticle acts as a lens Visual organs of this type are often called the *concentration-lens type* because their lenses usually cause a concentrated spot of light to fall on the visual cells Visual organs of this type are common among many arthropods, particularly insects and spiders, and hence are known as *arthropod ocelli* While these ocelli vary considerably in details, their essential features are similar (Figs 2A, 2B). The visual cells may remain in the epithelial layer or they may lie just below it. Sometimes the visual cells occur in groups with a rhabdom along their inner edges. There is evidence that these ocelli function primarily in the perception of the intensity and direction of light.

Ants with only their ocelli uncovered behave as if blind. The honey bee and the fruit fly (*Drosophila*) both respond more readily to changes in light intensity if their ocelli are uncovered.

The ocelli of the caterpillars of certain moths and butterflies are not true ocelli but are isolated ommatidia of degenerate compound eyes.

Simple Eyes

Since visual organs known as simple eyes are found in echinoderms, annelids and mollusks, they are rather widely distributed among invertebrate animals These eyes vary in structure from invaginated pits (Fig. 3A) to the specialized visual organs of *Murex* and the squid (Figs 3C, 4B) They have evolved from patches of visual cells in the outer body wall, forming first invaginated pits and finally simple eyes with a vesicle and lens These changes can be followed in present-day coelenterates and mollusks

The visual cells (retinal cells) of most simple eyes are enclosed within a vesicle, with their distal ends directed toward the incoming light rays There are, however, a few simple eyes among invertebrate animals in which the visual cells are inverted, as in the vertebrate eye. This is the condition in *Pecten* (Fig. 4A) and in the ocelli of certain spiders

The lenses of these simple eyes are usually formed by the secretion of certain cells and hence are not cellular structures. In the eye of *Pecten* and certain jellyfishes cellular lenses occur.

The simple eye of the chambered nautilus (Fig 3B) has neither a lens nor a vitreous body. Since the vesicle opens to the exterior by a small pit, the eye apparently functions as a pinhole camera. It seems probable that this eye represents a retrogression from a more specialized type of visual organ rather than an early stage in the evolution of a simple eye.

In certain arthropod ocelli and in some eyes of vertebrates the cells back of the visual cells contain a strongly reflective crystalline material which acts as a reflector, the *tapetum.* It is found in the eye of *Pecten* (Fig. 4A) and many other animals, particularly those of nocturnal habits. It is well developed in many moths, ungulates, carnivores and cetaceans. The eyes of cats show the reflection of light from the tapetum by glowing like balls of fire when light from an automobile flashes into them. The exact significance of the tapetum is not well understood. It seems certain, however, that the tapetum reflects light back through the visual cells upon objects that are in front of the eyes and thus may increase their discernibility.

Simple eyes are not limited to invertebrate animals since in certain vertebrates a median simple eye, the pineal eye, is found on the dorsal side of the head. It is a vestigial structure in many adult vertebrate animals but is functional in the primitive lizardlike animal *Sphenodon punctatum.*

In only a very few simple eyes of invertebrate animals, such as the more specialized cephalopods (squid, Fig. 4B), are there an iris and a pupil. Not until we reach the vertebrates do we find true crystalline lenses, eyelids, muscles for moving the eyes in sockets, and an effective mechanism for accommodation.

Simple eyes function in the detection of light, its intensity and direction. Many of them also serve their possessors for determining the distance of objects and as rudimentary image-forming eyes.

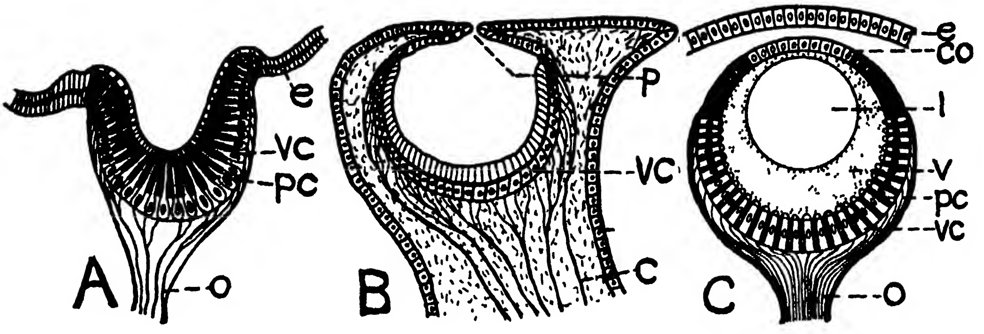

FIG. 3. SIMPLE EYES
(A) PITLIKE VISUAL ORGAN OF LIMPET (*Patella*); (B) PINHOLE TYPE OF SIMPLE EYE OF CHAMBERED NAUTILUS; (C) SIMPLE EYE OF SNAIL (*Murex*); (co) CORNEA, (e) EPITHELIUM, (l) LENS, (o) OPTIC NERVE, (p) PINHOLE, (pc) PIGMENT CELL, (v) VITREOUS BODY, (vc) VISUAL CELL.

Since all power of accommodation is usually lacking, it is probable that the perception of clear images rarely occurs.

Compound Eyes

Many arthropods, chiefly insects, possess two types of visual organs, ocelli and compound eyes. Sometimes both types are found in the same animal Many of these ocelli differ from compound eyes chiefly in the fact that the single ocellus possesses one focusing apparatus (lens) for all its visual cells, while compound eyes, which are composed of many units (ommatidia), have a separate focusing apparatus for each unit.

As shown in Fig. 2C each ommatidium is composed of retinal or visual cells, pigment cells, and a fixed focusing apparatus composed of a separate lens (crystalline cone) and a cornea. The edge of each retinal cell has a striated zone composed of the ends of many neurofibrillae, which are connected with

the optic nerve. The striated borders of all the retinal cells of an ommatidium which lie in apposition with each other are called a *rhabdom*. Although the compound eye has no power of accommodation, such as occurs in the eyes of most vertebrate animals, it is possible that the elongated rhabdom is an effective substitute since rays of light from both near and distant objects are focused upon it.

A single ommatidium of a compound eye and the individual retinal cells of vertebrates each receive light from a very small area of the outside world, and consequently the ommatidia are in that way comparable to the individual retinal elements of the vertebrate eye. Animals with compound eyes possess what is called *mosaic vision*. All vision, however, is probably mosaic, since perception of an entire object is dependent on the sum of the individual stimulations of numerous ommatidia or retinal cells.

Possessors of compound eyes react more to motion than to the details of images as in man, although insects have been observed trying to take nectar from flowers on wallpaper.

Among present-day species well-developed compound eyes are found only in crustaceans and insects, yet in a few sea-urchins (*Diadema*) a simplified compound eye occurs.

Accommodation Eyes

The power of accommodation, or the adjustment of the eye for perceiving distant and near objects, is generally considered to be a possession of only vertebrate animals. There is some evidence, however, that in the eyes of certain of the higher mollusks, such as the squid, the contraction of the sphincter muscle of the iris increases the pressure on the vitreous humor, which in turn causes the lens to be pushed forward, thus changing the focus of the eye from far to near.

Two methods of accommodation evolved in fishes. In many of the elasmobranchs the lens is pulled forward by muscles of the iris for the perception of near objects. When these muscles relax the lens automatically moves back to adjust the eye for far vision. In the second method the lens is pulled backward, for viewing distant objects, by a muscular band which extends from the region of the optic nerve to the surface of the lens, the falciform process (Fig. 4C). When this relaxes, the eye automatically readjusts for viewing near objects. The falciform process is especially well developed in many bony fishes, such as the genus *Salmo*. In amphibians, reptiles and birds the falciform process, now called the pecten, is no longer attached to the lens but is still connected to the optic

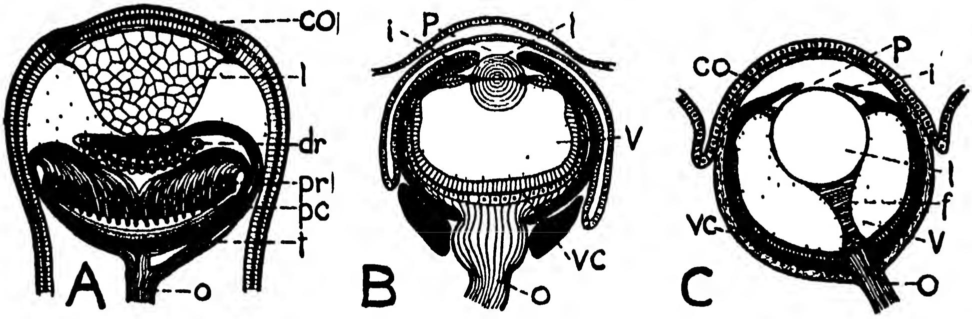

FIG. 4. SPECIALIZED TYPES OF SIMPLE EYES AND VERTEBRATE EYE
(A) EYE OF SCALLOP, DOUBLE RETINA; (B) IMAGE-FORMING EYE OF SQUID, (C) EYE OF VERTEBRATE; (co) CORNEA, (dr) DISTAL RETINA, (f) FALCIFORM PROCESS, (i) IRIS, (l) LENS, (o) OPTIC NERVE, (p) PUPIL, (pc) PIGMENT CELL, (pr) PROXIMAL RETINA, (v) VITREOUS BODY, (vc) VISUAL CELL.

nerve. In man the falciform process is rarely present in adult life but is present during fetal life as a thin, gray, vascular cord, which usually degenerates shortly after birth. However, it occasionally remains throughout life as a vascular cord extending from the optic nerve to the lens in the path of the old faciform process of fishes.

When the eye of man is at rest, the elastic choroid coat of the eye exerts a pull on the suspensory ligaments attached to the lens, causing it to become flattened. To accommodate the eyes for near objects contraction of the ciliary muscles counteracts the pull of the choroid coat, and consequently the lens through its own elasticity becomes more convex. In this way the eye is accommodated for viewing objects at different distances by changing the curvature of the lens.

Thus we see that visual organs with certain powers of accommodation probably did not make their first appearance in the vertebrates but apparently arose in certain mollusks closely related to the squid However, accommodation by changing the convexity of the crystalline lens occurs only in vertebrate animals.

Vertebrate Eye

As we pass from simple eyes to true accommodation eyes a great change in the eye at once becomes apparent. Where did this greatly improved eye originate? Some think that it was from arthropod ocelli, others from simple eyes, and still others from the ocelli of arachnids having inverted retinal cells. Nevertheless, it seems quite probable that vertebrate animals did not inherit their visual organs from the higher invertebrates, but that they developed eyes of a new and better type which involved three major differences: (1) a change in the origin of the visual cells (retina) from the outer body epithelium to the brain, resulting in an inverted retina; (2) a great increase in the number of retinal cells, with a differentiation of them into rods and cones; and (3) the development of the accommodation lens.

Representatives of all the major groups of animals, except Protozoa, are known to have visual cells in the body wall. Now that the primitive chordate, *Dolichoglossus kowalevskyi*, has been shown to possess visual cells in the nerve plexus of its outer body wall, it seems even more probable that the organs of vision in the vertebrates evolved from the visual cells in the body wall of the early chordates. It is probable that with the development of the central nervous system from the outer body epithelium of the early vertebrates the visual cells became incorporated in the central nervous system, as in *Amphioxus*, and later became localized in the region of the brain which forms the retina of the vertebrate eye.

WHY PUBLIC HEALTH EDUCATION?

By RUTH ALIDA THOMAS

DEPARTMENT OF HYGIENE AND BACTERIOLOGY, SMITH COLLEGE

THE holocaust of war is tearing away the last remnants of a smug national complacency and is opening our eyes to defects in our social structure In the field of public health, the shortcomings of the present stand out in bold relief against the possibilities of the future. We are apprehensive about the shortage of civilian doctors and nurses, but loath to admit that in the past we too often relied upon them to patch up the consequences of our own disregard of basic health principles. We are fearful that an epidemic will flare up in one of our overcrowded defense areas before we can muster our depleted resources for its control. We are aghast at the number of rejections reported by Army and Navy examiners for minor defects, the majority of which could have been prevented if adequately cared for in childhood. As the result of the present emergency we have overcome our lethargy, but the very speed with which we have had to plan for the health and welfare of both service and civilian groups necessitates a critical evaluation of objectives

Leaders in the fields of medicine, of sanitation and of public health have worked miracles in the past forty years in reducing the mortality from many of our common communicable diseases. The typhoid death-rate has dropped from 35.9 to 1.5, diphtheria from 43.3 to 1.5 and tuberculosis from 203.1 to 48 7, and yet all are still unnecessarily high. These servants of the public have taught us the importance of a balanced diet and have materially raised our standards of nutrition; they have provided our babies with a better and safer start in life. But in spite of these accomplishments, we have scarcely begun to sound the possibilities. As a result of the war, health has become, as never before, a community problem We are learning that the construction of barriers against the spread of epidemics is not enough—that a nation in need of manpower must be concerned with the positive health of each and every citizen Experience gained in meeting the needs of the present has made us realize that the projection of a vital, constructive post-war program will require the active participation of an awakened citizenry Looking to the long term, it is evident that the most productive means of acquiring the cooperation of Mr. and Mrs. Citizen is in effective teaching in the schools and, particularly, in the colleges Although rapid strides have been made in health education in recent years, yet in many parts of the country the actual health knowledge of the average adult remains woefully inadequate It is time to take stock of our present resources, and having set our goals, to direct our education to that end

The United States Office of Education is meeting the immediate problem by including education for health as a vital part of the Victory Corps program. Under the slogan, "health for victory," this program has wisely been developed for the high schools, since they are the acknowledged centers for the training of boys and girls, not merely for war service but for life. The objectives, as outlined, are comprehensive, even though they are drawn up with the primary purpose of making our high school youth physically fit for participation in various wartime activities The ultimate success of this program will depend upon its execution—upon the quality and scope of the teaching involved With motivation so strong, we must guard against the danger that it will be super-

ficial or one-sided. Given a sound scientific background and an understanding of the potentialities for or against health in ordinary life situations, such a program should have a "carry-over" into peace time which will materially increase the health of the average citizen.

We are building adequately for the future, however, only if we also instill a sense of social consciousness and community responsibility. One of the characteristics of our modern civilization is that we are increasingly interdependent upon one another The bright future which we envision for the post-war world will depend to a very considerable extent upon our concepts of public health—on constructive health measures beyond the control of the individual. We should no longer speak apologetically of our rural areas as "weak spots" but, recognizing that directly or indirectly we are each affected by health conditions beyond our immediate environs, we should be prepared to spend State or Federal funds to assure our country cousins' health benefits comparable to those provided in our most progressive cities. With a new interest in the health of our future citizens, we should not question the need for extension of our maternal and child health programs. Recognizing that many of our delinquency problems and a large proportion of the cases now cared for in mental institutions at public expense can be referred back to maladjustments capable of correction if studied in time, we should make use of the abundant knowledge being acquired through psychiatric research under Army and Navy auspices in building up community mental hygiene programs. We should face the problems connected with the non-communicable diseases peculiar to older age groups, to ascertain in what respects they are community problems.

The "post-war" world can be the "golden age" of public health if we give thought now to the appropriate education for the prospective citizens whose support we will so urgently need. In the inevitable shift from destruction to construction, the time will be ripe for an acceleration of our present efforts in the public health field. We will have an opportunity then, not only to strengthen our present work, unfortunately often demoralized by shortage of trained personnel, but to intensify our endeavors. We should be prepared to accept constructive health work as one of the functions of democratic government—as distinct from state medicine on the one hand and philanthropy on the other. Men returning from the Army and Navy, particularly the medical officers, will undoubtedly have become impressed with the values to be gained in health through community planning. Moreover, the great effort needed to maintain our civilian health services through the difficult war years, should be productive of far-reaching benefits It will be worthwhile if it precipitates a reshifting of emphasis in the work within each community in accordance with the seriousness of the problems and the chances for solution, and if it effects a closer tie-up between professional and voluntary agencies.

If we believe that there is room for accentuation and extension of our present public health programs in the post-war world, it is time for us to begin to plan for it. Through education we can train our young people to be alert to the health problems of their communities—to think in terms of social consciousness and communal responsibility.

The Victory Corps program should stimulate new interest in health education at the secondary school level, but on our colleges and universities will fall the responsibility of developing leadership. Already we find ourselves sorely in need of teachers equipped to initiate and carry through vital, stimulating health projects in the schools. We will need more professional workers and legislators with a background of public health to bolster health education in the com-

munities, but even more crucial will be our need for keenly interested citizens. The pace of progress will be proportionate to the public interest. For any effective work we must have key people in the various social groups to help search out and study the problems. We will have to find among the membership of our women's clubs and businessmen's organizations, men and women who, realizing that the local health board should be more than a politically dominated policing agency, will instigate the appointment of alert, progressive officials and then rally their fellow citizens to the support of their projected programs.

The scope of public health must be broadened if it is going to contribute materially to the realization of the opportunities and the way of life for which we are fighting. This will involve more than the protection of the community, by every means known to sanitary and medical science, from the spread of communicable disease. It will pose questions relating to housing, parks and playgrounds, and other esthetic measures whose relation to health cannot be definitely charted without consideration of the economic and sociological factors involved. Another moot question, and one which is already troubling school health administrators and child health workers, relates to the hypothetical borderline between preventive work and correction of defects—the definition of the legitimate boundaries of public health. Standards of nutrition and established measures in environmental sanitation and communicable disease control will have to be reviewed. Solutions will vary according to the character of the community, but each problem will involve not only a careful study by medical and lay experts but the farsighted consideration of each and every citizen, under intelligent and discerning leadership.

The future is bright for progress in the field of public health, but we must not be lax in assuring that future through well calculated education. The leadership of tomorrow will come from among the young men and women now serving in the armed forces, and from the students in our colleges and universities. A brief survey, however, will show that, while many colleges do include courses relating to public health in their curricula, they are frequently considered as vocational and designed primarily for students preparing to embark on a career of community service as prospective nurses and social workers. Without minimizing their value, it can be seen that such courses will have little appeal for the average student who is apt to shy away from them, being adversely conditioned often by repetitious health teaching in the lower grades and by the barrage of health propaganda, frequently misleading and fallacious, which comes to us by way of the radio, popular magazine articles and advertisements. The education which we need must be borrowed from several fields. It should embrace pertinent material from the various sciences and present these scientific facts against the rich background of history, tracing the development of modern medicine, sanitation and public health. It should study them in the light of their sociological import and their implications for social progress. The numerous factors influencing the health problems in different parts of the world should be reviewed and interpreted in terms of their bearing, either directly or indirectly, on our own national health. Such an education would not only help to fit our youth for intelligent, constructive citizenship, but would have outstanding cultural values as well. It is a worthy objective and one which can be attained readily if those interested in public health would endeavor to enlist the aid of school, college and university faculties in thus planning for the future. A nucleus of interest once aroused is bound to expand.

THE GIANT FRESH-WATER FISHES OF SOUTH AMERICA

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In another article I have described, with illustrations from photographs of just-caught specimens, the two largest fresh-water fishes of North America—the huge white sturgeon of the Columbia and Fraser Rivers, and that armor-clad living fossil, the alligator gar of the Mississippi and other Gulf-flowing waters. And now I turn for study to the giant fresh-water fishes of our southern neighbor.

In the great rivers of our twin southern continent are found many fishes to which the name giant may surely be applied First of these is the huge Pirarucu, which is found in the rivers of Guiana and in the Amazon; then the great catfishes which inhabit practically all large South American rivers from Guiana to the Argentine. Since South America is the continent of catfishes, it is not surprising to find that one of these Siluroids attains such great size that it is called Goliath.

Our knowledge of the distribution and particularly of the sizes attained by these great fishes is very imperfect; as a matter of fact, very scanty. Extensive collections and considerable study have been made of the smaller South American fishes, since these can be taken fairly easily, can be preserved and can be transported to museums for description and classification. Most collectors are not likely to get the big fellows Along these great rivers the population is thin, towns are generally small and far apart, and few persons, if any, are interested or able to catch, photograph, measure and weigh these great fishes Opportunities for scientific men to do so are also very few, and large specimens, for obvious reasons, rarely come to museums

Charles H Coles

FIG. 1. THE GIGANTIC OSTEOGLOSSID FISH, *ARAPAIMA GIGAS*

FOUND IN THE RIVERS OF GUIANA AND IN THE AMAZON. THIS MOUNTED SKIN IS 6 FT 9 IN LONG.

The Pirarucu, or *Arapaima gigas*

This great fish is common to the Orinoco and other rivers of Guiana, and to the Amazon and its tributaries, but is not found in the La Plata or other south-flowing rivers It has long been considered the largest fresh-water fish in the world, but, as has been and will be shown in other articles, this is an error. Its names are interesting; Pirarucu is the Indian name, from *pira*, fish, and *rucu*, red, because the reddish color of the great scales makes the whole fish look red, as may be seen in our mounted specimen in the Fish Hall of

Charles H Coles

FIG. 2 THE BONY TONGUE (6.7 INCHES LONG) OF A PIRARUCU

THE TONGUE OF THIS FISH, BECAUSE OF ITS VERTICAL TEETH, IS THE UNIVERSAL GRATER OF AMAZONIA

the American Museum The size of the scales (if not their color) may be noted in a photograph of this specimen (Fig 1) Arapaima is the Guiana Indian name, *gigas* is the Latin word meaning giant, and it surely fits our Arapaima Furthermore, this fish belongs to the family Osteoglossidae (*osteon*, bone, and *glossa*, tongue), those fishes which have bony tongues The tongue of our fish is covered with crowded rasp-like teeth Indeed the inhabitants of the Amazon Valley use these tongues as graters to reduce to a pulp coconut meat, manioc and other fleshy roots

This curious bony tongue apparently has never been figured and it seemed that this article would have to lack such an interesting illustration However, Dr. Harvey Bassler of our museum staff, during a long residence at Iquitos on the upper Amazon, collected and sent to the Department of Ethnology of the American Museum three of these curious implements They measure 3.6, 5 9, and 6 7 inches in length The two larger have been used as graters. Both had the interstices between the teeth filled with organic matter which, when softened with warm water, could be cleared away with a needle and a stiff brush The appearance of this curious natural implement is well brought out in Figure 2

The flesh of the Pirarucu is very palatable, and when cut into strips, salted and dried, it plays in the Amazon basin the part of bacon in the Mississippi Valley More narrowly, it may be said that, for the Amazonian riverines, it is the food counterpart of dried codfish in New England The cutting up and curing of the flesh of this great food fish has been carefully illustrated and described by Professor W R Allen of the University of Kentucky To his text and reproduced photographs, the inter-

After Eigenmann and Allen

FIG 3. THE FLESH OF THE PIRARUCU

THE "BACON" OF THE AMAZON VALLEY. IT HAS BEEN CUT IN STRIPS, SALTED, DRIED AND BALED.

ested reader is referred.[1] One of his photographs, showing the cured meat tied up in bundles like slabs of bacon, is reproduced in Figure 3

Arapaima gigas is gigantic, as its pictures show The ichthyology books (and the dictionaries also) say that, "It reaches a length of fifteen feet, and a weight of 400 pounds," but no one gives his authority All are like a flock of sheep—each following the one in front The man who said it first was Robert H Schomburgk On page 201 of his *Fishes of British Guiana--Part I*, published in 1841, he says, "I was assured by the inhabitants of the Rio Negro that they had caught some fifteen feet long and of twelve or thirteen arrobas (410 pounds) weight." Schomburgk calls attention to the small size of the caudal fin In a specimen eight feet one inch long, it was only five inches long and eight inches vertical when fully expanded This small caudal fin is very noticeable in Figure 1 which was made from our mounted specimen in the museum, and also in Figure 4 which was copied from Franz Keller's book, *The Amazon and Madeira Rivers* (New York, 1874) From a study of these figures it is clear that the red fish must be a slow swimmer.

Schomburgk states that the Rupununi, one of the head-components of the Essequibo, was in his day the only river in Guiana known to him in which the Pirarucu had been taken Interestingly enough, Figure 5, for which I am indebted to William Beebe and John Tee-Van, is of a fresh fish taken from the Rupununi The photograph was obtained from a passing traveler and, unfortunately, no other data concerning it were available. It is, however, the only figure known to me of a freshly caught Arapaima This photograph gives a very good idea not only of the size of the fish but of the shape and bulk. It is unfortunate that the fish was not suspended clear of the sandbar

I have not been able to find just how large the Pirarucu grows It is probable that Robert Schomburgk's fifteen feet in length may not have been an exaggeration for his day, but I feel quite sure that 410 pounds is too small a weight for a fifteen-foot fish of this heavy build All the figures (drawings and photographs) that I have seen show the fish with a massive logy body (Fig 4) The British Museum has stuffed skins seven and eight feet long, and a six-foot skeleton, all presented by Schomburgk The larger of these specimens had a girth of forty-three inches Our mounted skin measures six feet, nine inches over all It came to us from Para at the mouth of the Amazon but there is no record where it was taken

In 1909–1910, Dr J D. Haseman, under the auspices of the Carnegie Museum of Pittsburgh, made extensive collections of fishes on the upper Amazon, the Rio Negro, and their tributaries He states in a letter that at Meura, on the Rio Negro, at the mouth of the Branco, he measured the eight-foot skeleton of an Arapaima, said by the native fisherman to have weighed 120 kilos (265 pounds) At the same place the fishermen had caught another Arapaima, which they claimed to have been ten feet long and to have weighed 200 kilos, or 440 pounds. Haseman did not see the fish but did see the head. This was so much larger than the head of the one he measured that he thought the report of length and weight "reasonably accurate." Haseman states that these powerful fish, each provided with a bony tongue and mouth, not only tear up the fishermen's nets but even chicken-wire enclosures set in the rivers.

Parenthetically, it may be remarked that this region of the Negro (at the

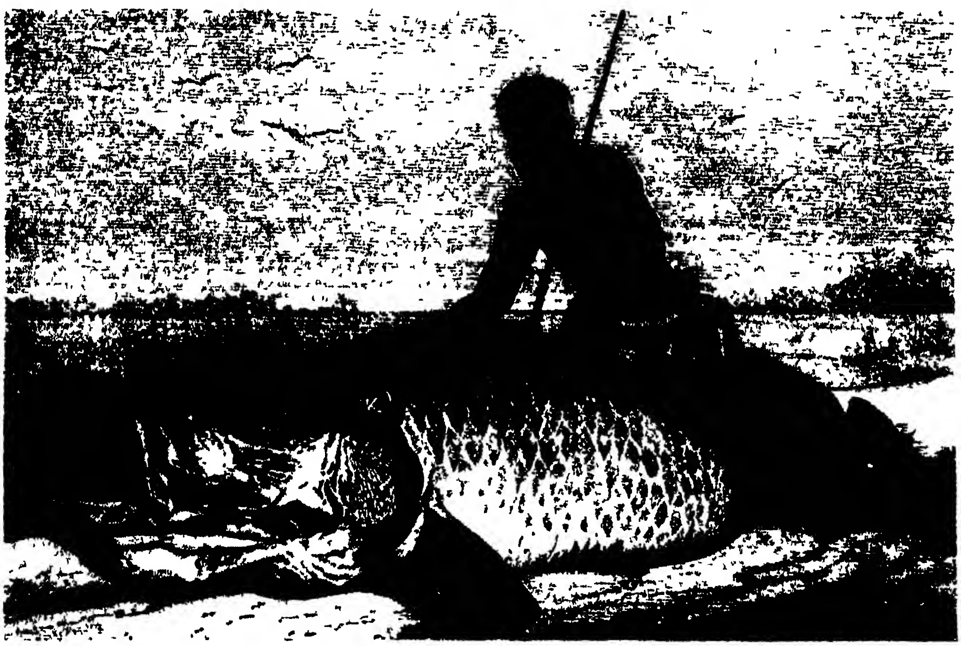
[1] C. H. Eigenmann and W R. Allen, *Fishes of Western South America*, University of Kentucky, Lexington, 1942. (Natural history notes on Arapaima, pp. 336–345, 6 figs.).

mouth of the Branco) is well known as a special habitat of Arapaima Robert Spruce, in 1868, speaking of his experiences there from 1850 to 1855—nearly 60 years before Haseman—says that. "About the mouth of the Rio Branco is the only [?] place in the Rio Negro where the Pirarucu is found—that noble and remarkable fish, so characteristic of the Amazon." If these various habitat notices are correct, there is much yet to be learned about the ecology of this fish

The latest estimator of the size and weight of Pirarucu is Allen (1942, p 338) The only one he measured taped seven feet, one inch, and his carefully considered judgment "would place the probable maximum size . . , at least in the upper Amazon, at about twelve feet and the maximum weight [at] 300 pounds" But Allen notes that due to overfishing the numbers of Arapaima are steadily decreasing The day of the big fellows would seem to be over

Haseman reports an interesting habit of the red fish on the Branco as follows: "About sunset these fishes come to the surface and make a tremendous explosive noise that can be heard over a quarter of a mile" The natives say that this is to get air, but Haseman concluded that it was made by a strong slap of the tail on the surface of the water. He offered no conjecture why this is done

This great fish's interesting method of reproduction is imperfectly known Its huge mouth, shown particularly well in Keller's figure, must be connected with its food and feeding habits and very probably with its method of reproduction Of the former we know practically nothing, but on the latter Schomburgk throws some light "The young are protected by the mother for some time after they leave the eggs [*i e*, hatch] just as in the case of the lau-lau [a giant catfish next to be studied], and swim generally



After Keller, 1874

FIG 4. A PIRARUCU FROM THE AMAZON RIVER

PARTICULARLY NOTICEABLE IS THE CAVERNOUS MOUTH IN WHICH THE YOUNG TAKE REFUGE.

William Beebe and John Tee Van

FIG. 5 A PIRARUCU FROM THE RUPUNUNI RIVER, BRITISH GUIANA

IT IS LONGER THAN EITHER MAN AND APPEARS TO BE ABOUT AS HEAVY AS BOTH MEN TOGETHER.

over her head." Oral gestation or buccal incubation (the carrying and holding of the eggs in the mouth of one parent or the other until they hatch) is definitely known to be practiced by two other Osteoglossids—one in the Amazon and the other in the rivers of Borneo. There is an extensive literature from 1768 to 1912 which alleges parental care by the Pirarucu and a number of the writers affirm that the eggs are carried in the gills. I have carefully studied all these accounts and find that they overwhelmingly point to oral gestation. The sex has not been determined in any of these Osteoglossid egg-carriers.

All accounts state that these great fishes are taken with the harpoon or with bows and arrows, rarely with the hook, and almost never in nets. Taken thus, the fish struggles violently and the eggs or young are likely to be disgorged. But perhaps some day some fortunate observer will by examination or by dissection find the eggs in the buccal cavity and determine the sex of the carrier.

The Great Catfishes of South America

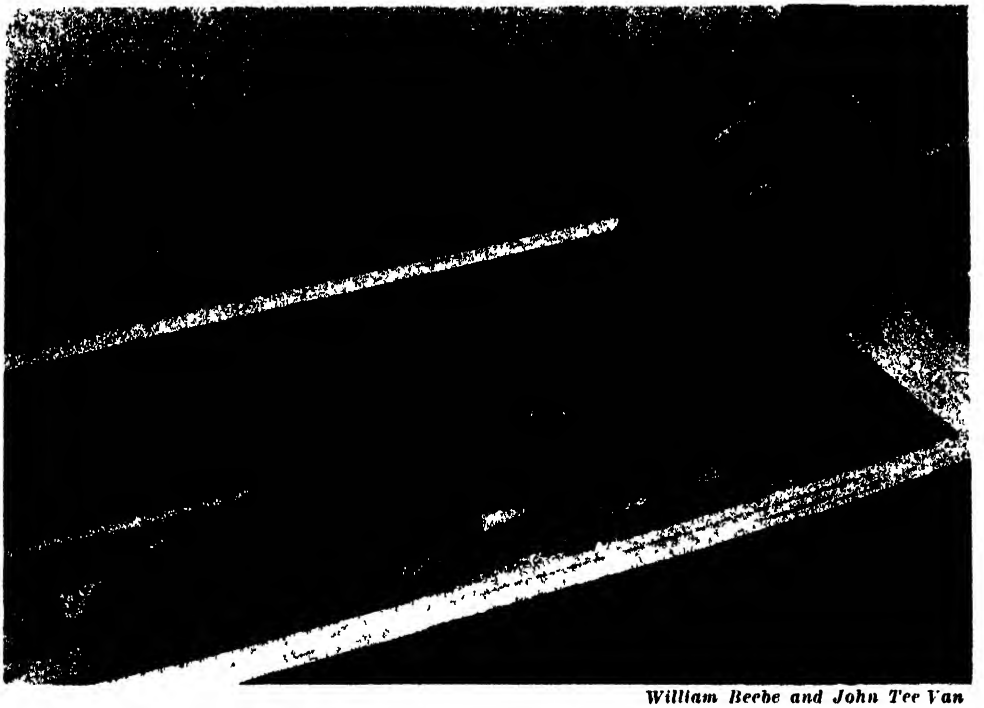
All the great rivers of South America are inhabited by huge catfishes. They are large and unwieldy and are com-

monly taken by fishermen lacking not only cameras for making pictures but also appliances for measuring and weighing these giants Consequently the information we have received is very sketchy Furthermore, scientists are rarely around when these huge fishes are taken, and because of their great size adult catfishes seldom come to museums

After Robert Schomburgk, 1841
FIG 6 SKETCH OF THE LAU-LAU
EARLIEST KNOWN FIGURE OF THIS GREAT FISH.

The Lau-Lau of the Guianas and the Amazon This great siluroid, whose scientific name is *Brachyplatystoma filamentosum*, is found in the Guiana rivers and also in the Amazon It and others of the genus are notable not only for great size but also for their long wide heads and huge gaping mouths—as our illustrations show Notable also are their prodigiously elongated filaments—the barbels or "whiskers" around the mouth which give these fishes the name "catfish" Lau-lau is the Guiana Indian name, which seems to have been first recorded by William Hillhouse in 1825 and by Robert Schomburgk in 1841 Hillhouse appears to have been the first to publish on the natural history of the Lau-lau In his book, *Indian Notices also the Ichthyology of the Fresh Waters of British Guiana* (Demerara, 1825), he says that the Lau-lau attains a length of twelve feet and a weight of 250 pounds

Robert Schomburgk gives us further natural history notes on this big siluroid He writes (1841) that "The



William Beebe and John Tee Van
FIG. 7. THE LAU-LAU, LARGEST CATFISH FOUND IN BRITISH GUIANA
THE GIANT OF ALL FISHES FOUND AT KARTABO NOTE THE BROAD HEAD AND THE WIDE MOUTH.

Lau-lau is, next to the Pirarucu (*Sudis gigas*), the largest fresh-water fish in the rivers of Guiana. . . They sometimes attain the length of ten or twelve feet, and the weight of 200 pounds, and their flesh is much esteemed." Their chief food is fishes, though they tend to be omnivorous. Their strength is in proportion to their size and they are strong swimmers Illustrative of these points, Schomburgk tells the following story, which also indicates how the fishes are caught

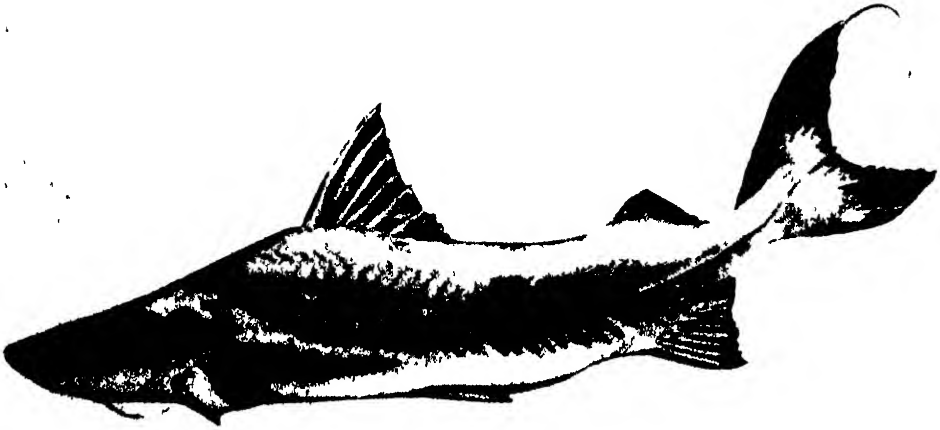
Sororeng, one of the Indians went late in the evening alone in a canoe, to try whether he could hook some fish We were all fast asleep, when I was awakened by some person crying out for help, and we soon ascertained that it was Sororeng, who had hooked a Lau-lau and having got entangeled in the line, with neither knife nor other sharp instrument at hand, the fish carried him and canoe at a rapid rate toward the cataract. Armed with cutlasses, we soon came to his assistance, and in time enough to prevent him from being carried down, but so eager was he now to secure his prize, when he saw that assistance was at hand, that he begged us not to cut the line, although it had, by this time, fairly cut into his hand, but to try to slay the monster, which apparently was more inclined to kill the fisherman than the fisherman the fish. It was slain and when brought to land, measured eight feet and a half in length

A good figure of this great catfish is greatly desired. Robert Schomburgk had with him an artist who made colored drawings of selected fishes, but for the Lau-lau he got no further than a mere outline sketch in pencil (Fig 6) This is the earliest representation of this huge

William Beebe and John Tee Van

FIG. 8. THE CAVERNOUS MOUTH OF THE CUMA-CUMA, GUIANA CATFISH

ALTHOUGH IT IS MUCH SMALLER THAN THE LAU LAU, THE MOUTH COULD HOLD A PECK MEASURE.



After Goeldi, 1911

FIG 9 THE PIRAHYBA, A GIANT CATFISH OF THE AMAZON

CLOSELY RELATED TO THE LAU LAU ITS NAME MEANS LARGE FISH THIS ILLUSTRATION PRESUMABLY WAS MADE FROM THE SEVENTY EIGHT INCH MOUNTED FISH IN THE PARA MUSEUM

fish, but even in outline it brings out the characteristics noted above

Robert Schomburgk's material came from the junction of the Rupununi and Essequibo Rivers, October 15, 1837 Ninety years later William Beebe and John Tee-Van studied specimens taken at Kartabo at the junction of the Cuyuni and Mazaruni Rivers, just six miles above where their united waters flow into the Essequibo I am privileged to quote from their unpublished manuscript and to reproduce an unpublished photograph of this great catfish (Fig 7) They state that this is "the giant of all the fishes found at Kartabo" The Indians told them of specimens twelve to fourteen feet long, and they found six-foot specimens to be fairly common.

The Lau-laus were caught at night on set lines with baited hooks sunk to the bottom in midstream Unlike Sororeng's fish, they offered little resistance and when a Lau-lau is caught " . the first evidence of its presence in the discolored waters is to see one sliding over the gunwale of the boat [in which it is brought ashore]. And when hauled into a boat, they are quite apathetic and seldom thresh about any" The passivity of these specimens may be attributed to the fact that, caught on set lines in the night, they have probably struggled for hours in the endeavor to escape and have literally become worn out

The two largest Lau-laus taken by Beebe and Tee-Van measured seventy-four and seventy-five and a half inches and weighed two hundred and two hundred and ten pounds respectively These measurements were from tips of snouts to bases of caudal fins, not "over-all" lengths, which, for our purpose here, are preferable The tail fin of a large fish would add about a foot to the standard length of the fish. In 1916, Beebe and Hartley measured a Lau-lau, taken near Kartabo, which stretched for eighty-three inches from tip of snout to base of tail, or about ninety-five inches (eight feet) over all

The flesh of most huge fishes is apt to be rank, "strong," but that of the Lau-lau is very palatable despite its size The capture of a big fellow is quite a gastronomic event and its flesh is peddled up and down the river to the no small satisfaction of the riverines

Wilderness (New York, 1914, pp 311–312)

> The huge catfish which the men had caught, . . with the usual enormous head, out of all proportion to the body, and the enormous mouth, out of all proportion to the head Such fish . swallow very large prey This one contained the nearly digested remains of a monkey, and . . once engulfed in that yawning cavern there was no escape . our Brazilian friends told us that in the lower Madeira and part of the Amazon near its mouth, there is a still more gigantic catfish which in similar fashion occasionally makes prey of man

This fish, called Piraiba, was said to grow over nine feet long While stationed at Itacoatira, a town on the Amazon at the mouth of the Madeira, the expedition's doctor saw one measuring nine feet This fish had been killed with machetes by two men, when its head rose out of the water alongside the boat from which they were fishing Swimmers are said to fear these big catfish more than they do the big caymans or crocodiles Colonel Rondon stated that on the lower Madeira, because of fear of the Piraiba, the villagers built stockades around their bathing places

The Mysterious Manguruyu, or Jahu, of the La Plata and Tributaries These names are given to a very large catfish found in the La Plata drainage There are several forms which belong to the genus *Paulicea* Possibly the best known one is *P lutkeni* This particular fish has an extraordinary distribution—from the shores of Guiana to the mouth of the La Plata. It has been recorded from the rivers of Guiana by Beebe and Tee-Van, and by others Brazilian ichthyologists have taken it in the Amazon. Haseman found it, under the native name "Jahu," in the headwaters of both the Madeira and the Paraguay-La Plata rivers That it is common to the Guiana and Amazon waters is easy to understand since the Cassiquiare links the Orinoco and the Amazon. But how it got into the Paraguay-Parana-La Plata waters is a great puzzle.

The fact that this great siluroid and scores of other kinds of fishes are common to both Amazon and La Plata tributaries is strong evidence that one or several connections formerly existed between these river systems I have seen maps which show the headwaters of one of the great southeastern tributaries of the Amazon arising in a swamp on a flat divide in Central Brazil, while out of the other side of the same marsh flowed a stream entering into the headwaters of the Parana Reclus, the great geographer, states that in 1772 a canal was cut through the narrow isthmus (about half a mile wide) separating the headwaters of the Guapore-Mamore from those of the Paraguay Furthermore, it has been stated that when these headwaters are in flood the flat divides are under water This matter is a most interesting side issue of the study of these great fishes Here is a field for a fascinating piece of geographical research

The Manguruyu is the largest fish found in the La Plata system Little, unfortunately, is know about its natural history and that comes mainly from the Alto Parana branch of the La Plata It has not been possible to find the origin of this native name of the fish

Emiliano MacDonagh[2] of the La Plata Museum has studied the Manguruyu negro, (*Paulicea lutkeni*), of which he had three fairly large specimens His largest fish measured sixty-seven inches His illustration made from the plaster cast in the Museum is reproduced here, since it is probably the best figure available of this large fish (Fig 10) It shows the Manguruyu to be a very heavily built and evidently powerful fish

C H. Cuthbert, Honorary Editor of the Dorado Club *Guide*, Buenos Aires,

[2] "Sobre el Manguruyu (Genero Paulicea, Siluroideos)," *Revista Museo de La Plata*, 1937, new series, vol. 1, pp 3 30, 14 figs.

After McCormick, 1937

FIG 11 THE MYSTERIOUS MANGURUYU

FROM A DRAWING BY A FRASER BRUNNER MADE FROM A SMALL SPECIMEN IN THE BRITISH MUSEUM

writes that "The Manguruyu is the largest of the catfishes in the La Plata system of rivers, and cases have been recorded of specimens being captured of over 300 pounds"

Some years ago, L J McCormick of Chicago visited Guayra on the Alto Parana and fished below the falls He writes interestingly of his experiences [3] Warned that the principal fishes there were so large and heavy that they would smash everything but the heaviest tackle, Mr McCormick, procured some heavy cord, tested to break dry at ninety-one pounds dead weight, and put on huge hooks baited with large pieces of raw meat One man got a bite but, powerful as he was, could not hold his fish Another man came to his help but the fish took the line from them both, cutting their hands badly in the process Other lines fastened to boulders were broken. Another was tied to a large tree limb as a float, but a fish took the bait and pulled the limb under water—almost doing the same thing with the fisherman—and then broke the line There was no holding these huge and powerful fishes "The whole *remanso* [a quiet backwater] seemed alive with monsters [but] the smooth surface of the turbid water gave no indication that anything stirred below" But the great fishes simply took the hooks, broke the heavy lines and went quietly about their business This account recalls what Dr Haseman wrote of his experience in hooking Pirahybas in the Amazon headwaters

Having with him his swordfishing harness, rod and reel, and hooks and line, McCormick made one more effort He got into his harness, boarded a canoe, baited a big hook, and fished swordfish-fashion A fish took the bait and hook and, despite the heavy reel with the drag on, it took also about 200 feet of line. "I wanted to play the fish, but at about [a speed of] five knots, it simply went cruising along in an unconcerned and exasperating manner." From which it seems that the fish reversed the usual role and

[3] *Fishing Round the World*, New York, 1937; Chapter 4, "The Mysterious Manguruyu."

played the angler The line then became fouled under water and, in attempting to loosen it, broke and the fish was lost. McCormick concludes. "My advice to those fortunate enough to voyage up the Alto Parana is to fish for Manguruyu—but to use a rope."

Although these great fishes at this very locality sometimes come to and roll at the surface, all of McCormick's fishes stayed at the bottom and, since they were never seen, no positive identification was possible—hence the title of his chapter on this fish However, the native fishermen believed that they were Manguruyus since there were in those waters no other fishes large and powerful enough to break such heavy lines In this conclusion all McCormick's South American friends and all ichthyologists consulted agree.

To illustrate this huge fish, McCormick, on the advice of J R Norman of the British Museum, had a drawing made of a small specimen of Manguruyu in that museum by the well-known English animal artist, A Fraser Brunner (Fig. 11) The angle at which the drawing presents the head gives some idea of the width of mouth and head but not of the length of head

How large this great catfish grows is not known. The Dorado Club in Buenos Aires in its *Guide* for 1937 has unverified reports of very large ones One measured sixty-six and one half inches in length, forty and one half inches girth, and the head length thirty-one inches—nearly half the length of the fish. Its weight was not taken but it was estimated at about 200 pounds Another, when caught and pulled to the surface, was so huge that a horse was required to drag it ashore It was reported to be seven feet long and to weigh 220 pounds A third when hooked pulled the fisherman out of his canoe but he hung on and was rescued by his friends Then the fish took charge of the canoe and towed it down stream about seven miles and was subdued only after a three-hour fight No length is given but the fish is said to have weighed 308 pounds. Next, Sir Christopher Gibson reported having found, left stranded by a receding flood, "a Manguruyu skull which was over 6 feet in length." The fish was judged to have been thirteen or fourteen feet long and to have weighed about 660 pounds In support of this, it is said that "the naturalist Ambrosetti mentions obtaining specimens over 4 metres (14 feet, 6 inches) from the river near the town of Parana."

These statements are all made by non-scientific men: Sir Christopher Gibson does not say that he put the tape on his huge skull, and I have not been able to locate and identify "the naturalist Ambrosetti"—consequently they must be taken for what these accounts are worth But as the late Dr F A Lucas wrote, "All fishes shrink under the tape" Hoping to get authentification for these accounts, I wrote to Cuthbert but he could not get any further data However, he wrote to Sir Christopher and sent me a copy of his answer I quote from Sir Christopher's letter—italics and all.

> The skull I saw . *was* 6 feet in length, but at the time—so long ago—I never realized the importance of preserving such a valuable specimen. However, I *believe* I am right in saying that the total length of the skull is greater than half the total length of the fish, which would make this particular fellow, say 11 feet long or . . . say 250 kilos [550 pounds]

Undoubtedly Sir Christopher saw a huge catfish skull, but he did not measure and preserve this unique specimen This is most unfortunate and regrettable Had he done so there would be something tangible whereon to estimate the length of the fish. The length of a fish is reckoned thus—Head in body x times, and the "head" is measured from snout or mouth tip to tip of bony gill-cover. But

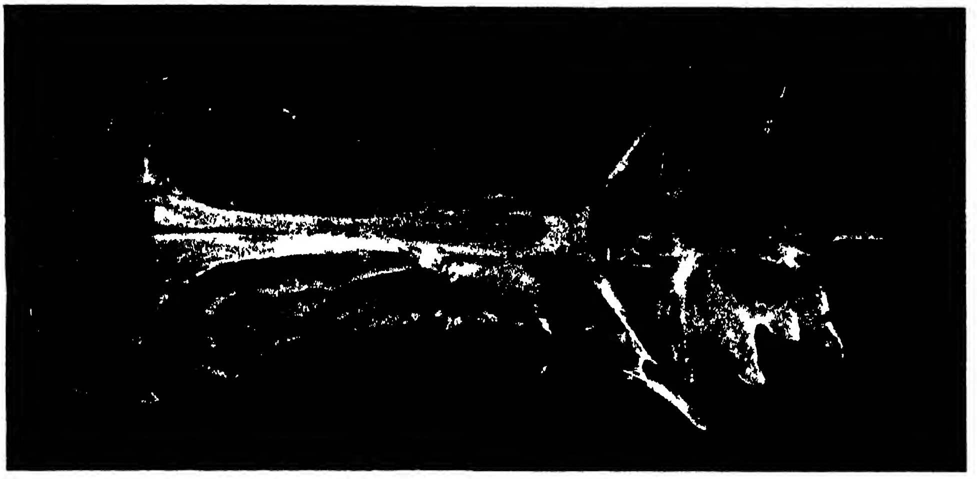


FIG 12 "SKULL" OF A GIANT CATFISH
THE *Brachyplatystoma filamentosum* FROM BRITISH GUIANA THE SKULL PROPER ENDS AT THE JUNCTION INDICATED BY THE ARROW TO THE RIGHT OF THIS IS THE "VERTEBRAL COMPLEX"

when the head is macerated, and the loose bones (gill-covers, jaws, etc) fall away, the solid bony skull is left This is generally somewhat shorter than the head as defined above, but not always so However, the "skulls" of many catfishes are extraordinary structures—much longer than the head as defined

This is seen in Figure 12 Here the base of the skull proper is marked by the arrow and to the right are several vertebrae and their transverse processes solidly fused into a unit mass called the "complex vertebra" This is so firmly joined to the base of the true skull as to be essentially a part of it The number of these vertebrae varies from five to eight in various catfishes The skull figured here in ventral aspect is from one of Dr William Beebe's huge British-Guiana catfishes—*Brachyplatystoma filamentosum.* Here seven and possibly eight vertebrae and their lateral processes are fused to make the vertebral complex

In the specimen figured, the complex vertebra greatly elongates the "skull" as in that seen by Sir Christopher Gibson The total over-all length of the skull as portrayed (Fig 12) is 472 mm (18 6 in) but of this the vertebral complex measured from the base of the skull backward is 126 mm (4 95 in) Then the length of the true skull is 346 mm (13 6 in) and it is clear that the complex vertebra comprises or adds 36 per cent to the length of the "skull" in Sir Christopher's phraseology If the same proportions hold true in the skull seen by him, then the true skull must have measured less than four feet long and the length of the fish that bore it must have on his calculation ("body = head × 2") been about eight feet in length

Furthermore in this matter of head-length body-length proportions in the Manguruyu, we have positive evidence from MacDonagh. He had in the La Plata Museum three fairly large specimens and for these he gives the following proportions. (1) in a fish 1455 mm long, the head was contained in the body 3 43 times; (2) 1555 mm, long, and head length in the body 3 57 times, and the proportion for (3) one 1680 mm long was 3 33 times None of these proportions approach the fish of 68 5 in with a reputed head length of 31 in or 45 per cent of total length. These last measurements were probably erroneous

EXPLOSIVES—VERSATILE TOOL OF INDUSTRY AND WAR

By Dr. JAS. K. HUNT

E. I. DU PONT DE NEMOURS AND COMPANY

RECENT announcement by Major General L. H. Campbell, Jr., Chief of Army Ordnance, of a new explosive said to be 35 per cent more powerful than TNT (trinitrotoluene), has stimulated fresh interest in the whys and wherefores of explosive materials. What is an explosive, what is the source of its power, what causes it to "go off," and how is its energy measured? Do explosives have important uses other than in guns, bombs, torpedoes, and other military devices?

Strange as it may seem to those who think of explosives largely in connection with war, materials of this type are used chiefly for peaceful jobs. Commercial explosives, such as dynamite, blast out coal, ores and rock, and speed the construction of dams, tunnels, highways and harbors. For such jobs, in a normal year, the United States consumes some 350,000,000 pounds of dynamite. The total this year may reach 450,000,000 pounds. In laying the "Big Inch," the world's largest pipeline, to bring oil from Texas to the East, approximately 750,000 pounds of dynamite were used. From scores of plants throughout the country, this versatile product is rolling to the mines to speed production of vital metals and coal.

Dynamite unquestionably ranks among the great labor-saving "tools" of all time. With fifteen cents worth of this explosive, and another fifteen cents worth of drilling, some four to six tons of rock may be put into useful form. History records that 100,000 slaves labored thirty years to build the great pyramid of Giseh. Grand Coulee Dam, a structure three times as large, was built in a fraction of the time and with a fraction of the workers—with the aid of dynamite. But, like other useful tools, explosives may destroy as well as build, and in time of war military explosives, such as TNT and smokeless powder, take the spotlight.

No simple definition would fit every explosive. All of them, however, are substances which, suitably stimulated, decompose with violence. That is, they go off with a "bang." Chemically speaking, the extremely rapid reaction that occurs when an explosive goes off involves the breaking down of one relatively large molecule into a number of rather small molecules. In the case of most common explosives, the decomposition products are chiefly molecules of such simple gases as carbon dioxide, carbon monoxide, nitrogen, hydrogen, and water vapor. Some explosives, however, form no gases when they go off. In the explosion of copper acetylide, for example, the decomposition products are carbon and copper—both solids. There is little or no recombination of the simple decomposition products—either gaseous or solid—into more complex molecules.

The stimulus required to set off explosives varies widely. Compositions based largely on ammonium nitrate, unless sensitized with nitroglycerin or similar material, are so insensitive to shock as to require special primers or detonators. For example, the ultra-safe "Nitramon" blasting agent, employed chiefly in rock quarrying, uses a primer based on TNT. An ordinary dynamite blasting cap does not provide sufficient "kick." TNT itself is capable of with-

Courtesy Du Pont Company

BLASTING THE TRENCH FOR "BIG INCH"

ONE OF SEVERAL BLASTS MADE TO CREATE THE RIVER BED TRENCH FOR "BIG INCH" IN RECORD TIME.

standing a severe shock without exploding. Otherwise it could not be used as the bursting charge in shells shot from big guns. Other explosives, such as nitrogen iodide, may be set off by the gentle touch of a feather.

The use to which an explosive is put depends in part upon its sensitivity to shock. This can perhaps best be illustrated by considering the several different materials used in high-explosive shells, such as those fired from large-caliber naval guns. The explosive train in the simplest type of high-explosive shell consists of three materials: the primer, the "booster," and the main bursting charge.

For the primer, which is located in

Courtesy Du Pont Company

LOADING A 25 LB CARTRIDGE OF 60 PER CENT GELATIN DYNAMITE

THE CARTRIDGES WERE LOWERED THROUGH STEEL CASINGS INTO DRILL HOLES AND FIRED TO BLAST A DITCH IN THE RIVER BED FOR "BIG INCH," THE WORLD'S LARGEST OIL PIPELINE

the nose of the shell, a small charge of a rather sensitive explosive is used, such as lead azide or fulminate of mercury This primer charge is set off by percussion when the shell strikes something solid, or by a timing mechanism as is employed in some anti-aircraft shells which are set to explode at any desired altitude Although the material used as a primer must be sensitive enough to be set off when the shell strikes a solid object, it must be capable of withstanding a certain amount of shock, otherwise, accidental explosions would be frequent.

Next in the explosive train of the shell may come the "booster" charge, trinitrophenylmethylnitramine ("tetryl") being typical of this class of explosive. "Boosters" are less sensitive than the primer, but more sensitive than the HE (high explosive) bursting charge. The "booster" makes it necessary to use only a small amount of sensitive and relatively dangerous primer, and insures complete detonation of the relatively insensitive bursting charge—usually TNT, Amatol (TNT and ammonium nitrate), or, for armor-piercing shells, ammonium picrate Considerably more "booster" is used than primer, but even then the "booster" charge is small in comparison with the HE bursting charge. It is the charge of HE which does the damage in the so-called "block-busters"

Frequently a time fuse is used to delay detonation of the bursting charge until, for example, the shell has passed through the armor plate of a battleship—a sheet of steel twelve inches or more in thickness Slow-burning black powder is commonly used in such time fuses, the effective length of which is controlled by a dial setting on the nose of the shell. When a black-powder fuse is employed

to delay detonation, the train of explosives in the shell usually consists of primer, time fuse, detonator, "booster," and HE bursting charge

The detonator used in such an explosive train may be identical in composition with the primer, and is necessary because the black-powder fuse alone would not set off the relatively insensitive "booster." The explosives used as primers and detonators, although not necessarily extremely powerful (as compared with certain other explosives), are materials which deliver their energy rapidly and at extremely high pressure In fact, some detonators develop pressures of the order of two and one-half or three million pounds per square inch

All explosives are decomposed by heat, but with some—dynamite, for example—a rather severe shock is generally necessary to cause the instantaneous and violent decomposition known as "detonation" To bring about the necessary shock a metal cap containing a suitable detonator is attached to the dynamite This cap may be fired either by a black-powder fuse or by an electric current

Large volumes of gases are set free when most explosives go off Furthermore, the temperature of an explosion may be 5,000 degrees Fahrenheit, or over, which greatly expands the liberated gases As a result, the volume of hot gases formed may be from 10,000 to 15,000 times the volume of the exploded material It is the large volume of gas liberated when smokeless powder burns that "propels" the shell out of a big gun and sends it on its deadly mission, possibly twenty-five miles away The pressure of this gas, incidentally, rises sharply to a maximum—around 36,000 pounds per square inch in a sixteen-inch

Courtesy Du Pont Company

UNLOADING "BIG INCH" PIPE BESIDE THE SUSQUEHANNA AT MARIETTA, PA

ABOUT SIXTY THOUSAND POUNDS OF 60 PER CENT. GELATIN DYNAMITE WERE USED TO BLAST THE TRENCH IN THE SOLID ROCK BED OF THE RIVER BOTTOM IN WHICH THE BIG PIPE RESTS.

gun—before the projectile has traveled one-fourth the distance from breech to muzzle, after which it falls off gradually.

The energy of an explosive depends upon several factors, including the volume of gases produced and the amount of heat given off. It is commonly determined by shooting a definite amount of the explosive in a "ballistic mortar," a device somewhat like a heavy swinging cannon, and by observing how much swing is imparted to the mortar by the "kick" of the explosion. The greater the swing, the greater the energy. The energy or "strength" of an explosive is commonly expressed in terms of TNT, the standard of comparison in the United States. Equally important as *amount* of energy, however, is the *rate* at which the energy is liberated, since this determines the usefulness of explosives for various purposes.

Explosives are divided into two main types, propellants and high explosives, depending upon the speed at which they burn or decompose. The faster the burning, the faster energy is released. In turn, rate of burning depends upon such factors as particle size, density, and pressure.

Black powder, first used as a propellant by the English in 1346 in the battle of Crécy, burns at a rate of only a fraction of an inch per second in the open air. Confined, however, so that a high pressure is built up, the rate of burning may be ten or more times as great. The rate of combustion of smokeless powder likewise increases with pressure, but in no case—in a sixteen-inch gun, for example—does the average rate exceed three or four inches per second. In contrast, the velocity of detonation of a high explosive, such as dynamite or TNT, may exceed 20,000 feet a second.

The burning rate of smokeless powder is measured by firing a weighed charge in a closed chamber and measuring the rate of pressure rise with a piezo-electric gauge—a device which converts pressure on a quartz plate into an electrical impulse. Electronic amplifiers and a cathode ray oscillograph translate the electrical impulse into a visible trace which may be recorded photographically.

With this technique the burning characteristics of numerous propellants have been examined. The observations are consistent with the theory that smokeless powder burns only on the surface, that the decomposition takes place rapidly and completely in the neighborhood of the surface, and that the rate of burning—and accordingly the rate of gas evolution—is essentially proportional to the first power of the pressure of the gaseous products. In other words, if the pressure is doubled, the rate of burning is about twice as great.

Nitrocellulose-base cannon powders, such as those used by the U. S. Army and Navy, burn with a linear velocity of approximately one-fifth of an inch per second per thousand pounds of pressure per square inch. At 20,000 pounds per square inch, which may be taken as the average pressure in a modern field piece, the linear rate of burning is accordingly about twenty times as great, or around four inches per second.

Since the total time, from the firing of the primer to the time the projectile leaves the gun, is only a few hundredths of a second, even for the largest gun, it is evident that the least dimension of the powder grains must be quite small to insure fairly complete combustion before the projectile reaches the muzzle of the gun. The fact that the rate of gas evolution is proportional to the area of powder surface makes careful control of the burning surface essential in order to keep the gun pressures within the bounds of safety, which is of the order of 40,000 pounds per square inch. During manufacture not only must the chemical composition of a propellant be held constant to insure a product of uniform potential

energy, but the linear dimensions of the grains must be held within close tolerances to furnish material with the desired specific surface. These precautions are necessary in order to insure ballistic properties as nearly uniform as possible.

The ordinary present-day cannon powder liberates approximately twenty-eight cubic feet of hot gas (measured at atmospheric pressure) per second from each square inch of powder surface when burning under a pressure of 20,000 pounds per square inch. At greater pressures the rate is proportionately higher.

Because rate of burning depends on the size and shape of the powder grain, it is only natural that a great variety of geometrical forms has been tried. Strips, tubes, cubes, flakes, cords, spheres and multiperforated cylinders are some of the shapes which have been produced for various services. A short cylinder, with seven perforations parallel to the axis, is preferred in this country for use in cannon because the surface of powder in this form *increases* during combustion, whereas the surface of an unperforated cylinder grows smaller as burning progresses. This increase in area, which means an increase in rate of gas evolution, helps to sustain the pressure in the gun barrel in spite of the increase in volume behind the projectile as it moves down the bore of the gun.

The powder grains used in U. S. sixteen-inch guns are cylinders about two inches long and approximately seven-eighths of an inch in diameter, with seven uniformly-spaced perforations parallel to the cylinder axis. These perforations, which are nearly one-sixteenth of an inch in diameter, are arranged in the form of a hexagon (end view), the seventh hole being in the center of the hexagon. With a grain of this type the *web thickness*—that is, the minimum thickness of the grain between any two boundary surfaces—is less than one-fourth of an inch.

Since each multiperforated grain of smokeless powder burns in parallel layers in directions perpendicular to all ignited surfaces, and since each grain is ignited all over—inside and out—at the same time by the flash from a charge of black powder, the web thickness (about one-fifth of an inch in this case) represents the maximum thickness of smokeless powder that must be burned before the grain is almost completely consumed—not *completely* consumed, because twelve small slivers of triangular cross section remain when the web thickness has *just* burned through. However, these slivers are usually consumed before the projectile leaves the gun. This means that the total propellent charge—weighing up to 800 pounds in a sixteen-inch gun, and occupying a volume of some twenty-three cubic feet—is burned in a fraction of a second.

Although the rates of burning, mentioned above, for propellants appear rapid when compared with the rates of ordinary chemical reactions, they are actually quite slow in comparison with the velocity of detonation of high explosives, which, as indicated above, may exceed 20,000 feet a second. In fact, dynamite, TNT, or ammonium picrate would explode with such rapidity and violence as to burst the gun if an attempt were made to use one of these high explosives as a propellant. Unfortunately, premature explosions of HE shells sometimes do occur, due to some accidental cause, always with disastrous results to the gun, and sometimes to the gun crew as well. On the other hand, high explosives are just the thing for the bursting charge in bombs, shells, and torpedoes, where a quick-acting, disruptive explosive is desired.

Paradoxical as it may seem, the energy of the high explosive in a shell is actually much less than the energy of the smokeless powder used as the propellant. Again taking a sixteen-inch gun as an example, the propellant charge of approximately 800 pounds of smokeless powder has some 1,000,000,000 foot-

pounds of energy, in comparison with about 530,000,000 foot-pounds for 410 pounds of TNT, which represents the weight of an average bursting charge for the shells fired from guns of this caliber Pound for pound, however, smokeless powder and such high explosives as TNT, Amatol, and ammonium picrate have very nearly the same energy

Most explosives contain nitrogen and oxygen Usually, one nitrogen atom is associated with either two or three oxygen atoms Nitrogen and oxygen are commonly introduced into the explosive molecule by a process known as "nitration," which involves treating a suitable organic material with a mixture of nitric and sulfuric acids Thus, nitrocellulose, the base of smokeless powder, is made by the nitration of cellulose in the form of purified cotton linters or wood pulp Similarly, nitroglycerin, the base of dynamite, is made by nitrating glycerin, derived from fats, and TNT, by nitrating tolnol, derived from either coal tar or petroleum

In addition to nitrogen and oxygen, most explosives contain carbon and hydrogen also This is the case with TNT, nitroglycerin, and nitrocellulose.

Now nitrogen is a peculiar, lone-wolf sort of element Unlike carbon, hydrogen, and oxygen, it does not wish to unite with, or stay joined to, another element It much prefers to go its way alone So, when the proper stimulus is applied to a material such as TNT, the large, nitrogen-containing molecules fly to pieces with great violence, giving rise to smaller, simpler molecules. The nitrogen, as might be expected, goes off alone, carbon and oxygen may be united either as carbon dioxide or carbon monoxide gas. Likewise, the hydrogen may be combined with oxygen in the form of water, not liquid water, which is relatively dense, but gaseous water, which occupies a large volume Any excess oxygen is set free as such In the typical explosive, all products are gases, but as mentioned previously in the case of copper acetylide, the decomposition products may be solids Black powder is another exception to the general rule, which explains why it fouls up a gun so badly. Here the solid residue is about three-fifths the weight of the original powder

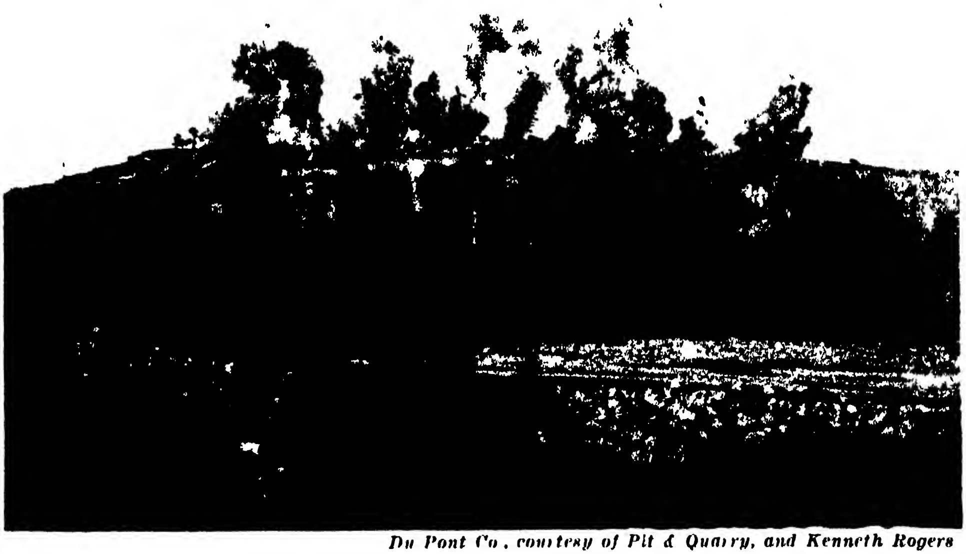
Interesting yet highly destructive explosives are fine particles of combustible materials—coal, sugar, flour, cork, wood --floating in the air. Some of the most frightful explosions on record have resulted from the ignition of such "carbonaceous" dust, particularly in coal mines and flour mills Fortunately, such accidents are now quite rare, due largely to precautions which keep down dust

The explanation of dust explosions is simple. Each tiny combustible particle is surrounded by atmospheric oxygen with which it wishes to unite, and only the flame of a match or an electric spark may be required to set off the reaction which proceeds with explosive violence throughout the entire mass of air and dust According to the U S Bureau of Mines, mixtures of coal-dust and air will not explode if the dust concentration is kept under 20,000,000 particles per cubic foot. One method for reducing dust concentrations in coal mines is to sprinkle with water containing a wetting agent, such as one of the fatty alcohol sulfates.

Metals as well as carbonaceous matter may behave in this way. Although aluminum is not commonly regarded as combustible, in the form of a fine powder suspended in the air it has been the cause of disastrous explosions. Like particles of coal or flour, tiny particles of aluminum, if heated beyond a certain temperature, combine with oxygen in the air with explosive violence. For this reason, aluminum powder is usually made by grinding the metal in an inert atmosphere such as nitrogen

A mixture of gasoline vapor and air in the cylinder of an automobile is not

unlike a suspension of fine, combustible dust particles in the air When ignited, each burns with great rapidity In fact, gasoline vapor in the cylinder of an automobile may sometimes burn too fast for maximum engine efficiency Such is the case when "knocking" occurs Here the combustion of the gasoline vapor proceeds with explosive violence The rials For example, a pound of TNT actually yields fewer units of energy than a pound of coal, and nitroglycerin, even if it could be "tamed" for use in running an automobile engine, would not be as good as gasoline, since, pound for pound, it cannot do as much work as gasoline An explosive appears extremely energetic simply because all its energy



Du Pont Co., courtesy of Pit & Quarry, and Kenneth Rogers

BLASTING 69,360 TONS OF ROCK AT A SINGLE SHOT

TO DISLODGE THIS GRANITE MASS 19,266 POUNDS OF NITRAMON BLASTING AGENT WERE USED.

gasoline-air mixture actually detonates, in somewhat the same way as TNT What is desired is not detonation, which results in energy being liberated too fast for efficient use, but a rapid, yet controlled, burning of the gas mixture A few drops of tetraethyl lead per gallon of gasoline does the trick

Contrary to popular opinion, the energy in a given amount of high explosive is no greater than the energy in the same amount of certain non-explosive mate-

is set free practically instantaneously, whereas it may take half an hour to burn a small lump of coal.

In this connection it is interesting to note the magnitude of the power generated by explosives in some typical applications A sixteen-inch gun fires a projectile weighing more than a ton at a muzzle velocity in excess of half a mile a second The kinetic energy of the projectile—approximately 265,000,000 foot-pounds—is acquired in the period of

about five-hundredths of a second during which the projectile travels from breech to muzzle. In this brief interval, the smokeless powder charge is delivering nearly 10,000,000 horsepower, which is approximately ten times the power of the combined Canadian and U S hydroelectric plants at Niagara Falls. A field gun of approximately six-inch caliber requires in excess of a million horsepower These examples show why little success has been achieved by occasional attempts to obtain satisfactory ballistics with electrical guns consisting of a series of solenoids and other devices dependent upon the usual power sources.

From the preceding it is clear there are explosives, and explosives—and yet other explosives They are "tailor-made" for a particular use. Dynamite detonates too rapidly to be used as a propellant, and is too sensitive for use as the disruptive in the big shells shot from guns The shock of the propellant would set it off before the shell reached the end of the barrel. But TNT, Amatol, and ammonium picrate are so insensitive as to withstand such shocks, yet are powerful enough to do great damage when they do go off. On the other hand, smokeless powder does not release its energy fast enough for use as the bursting charge in shells, bombs, and torpedoes, yet is almost ideal as a propellant.

While no explosive is designed as a child's plaything, some are relatively gentle while others defy taming. If suitable precautions are taken, however, the manufacture and use of commercial explosives present no greater hazard than is encountered in many industries commonly regarded as quite safe. In fact, the personal injury frequency rate for all Du Pont explosives plants—both commercial and military, is definitely lower than that of industry as a whole But, like "tame" lions and tigers, even the "gentlest" explosive should be handled with care by an expert to prevent accidents.

FRIEDRICH MIESCHER, 1844–1895

FOUNDER OF NUCLEAR CHEMISTRY

By Dr. JESSE P. GREENSTEIN

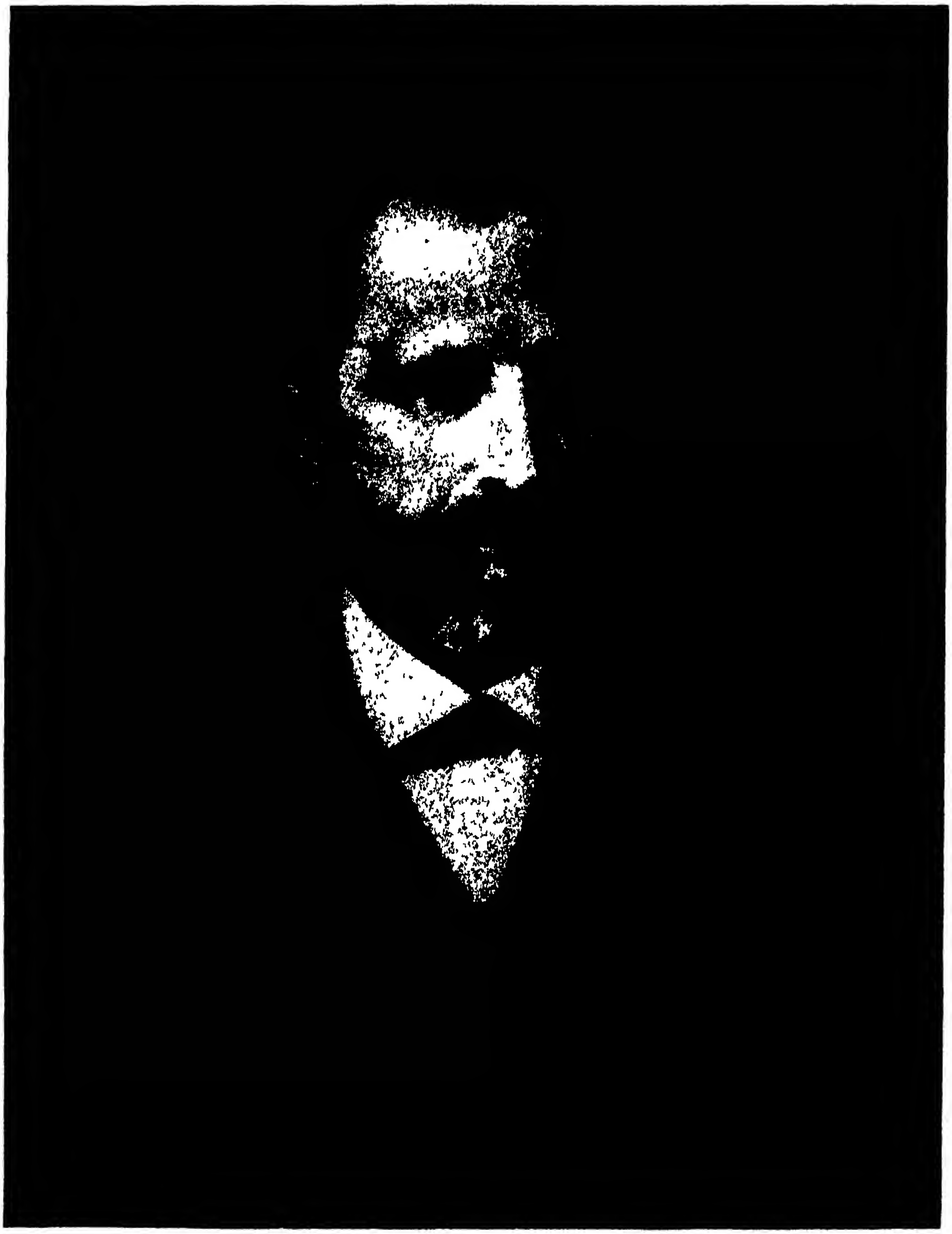
THE NATIONAL CANCER INSTITUTE, NATIONAL INSTITUTE OF HEALTH, U S PUBLIC HEALTH SERVICE

THE year 1944 marks the one hundredth anniversary of the birth of Friedrich Miescher, in Basel It is appropriate at this time to recall the fundamental contributions of this distinguished pioneer in the development of biological science, and to assess these contributions in the light of the present knowledge of the subject. The stature of some men's work, if not its value, diminishes with time, and the appraisal of such work assumes largely an antiquarian interest. Chance, as a by-product of uninspired plodding, sometimes plays a major role in great discoveries But, on the other hand, the work of some men appears to be immortal and forever new. This is because it rests upon approaches and procedures which men of science recognize as truly valid, namely: (a) the proposal of the problem in clear and unmistakable terms, (b) the conduct of the experimental solution of the problem by impeccable and sternly disciplined techniques, and (c) the interpretation of the results obtained with cool yet imaginative insight.

Miescher belonged to this latter category of workers, and in the perusal of his works the reader feels strongly their enduring quality. Briefly stated in terms of the above framework, Miescher set forward. as his essential problem; (a) the identification in chemical, as well as morphological, terms of the unique structural element of the cell, the nucleus; (b) the physical isolation and identification of the nuclear components by choosing the best available material and by employing techniques, without regard to personal comfort, which yielded the desired components in nearly unaltered form; and (c) picturing the nucleus on the basis of study of the properties of the components as a dynamic and interrelated system, the equilibrium position of which altered in response to changes, whether of intrinsic or of extrinsic origin, of any one of the components

Miescher came of a family long distinguished in the professions. His father, one of the earliest pupils of Johannes Müller, in Berlin, was for some time professor of pathological anatomy in Bern, and later in Basel. The son studied medicine in Basel, where he had the good fortune to come under the influence of the anatomist His. First pupil, then colleague and life-long friend of His, Miescher's letters to the latter portray, even more than do his scientific papers, the thoughts which motivated his career His early steered his young friend into the field which now is known as histochemistry, for, as the former expressed it, "in my own histological studies I came to the conclusion that the final solution of the problems of tissue development could be solved only by chemistry " It is easy to smile at His' optimism, but his statement reflects the creditable desire of the biologist to express his findings with greater precision The replacement of biological by chemical terminology is probably not a "solution" of the problems as His envisaged it, but the latter terminology may more frequently be employed with greater clarity than the former.

Miescher obtained his doctor's degree in Basel in the spring of 1868 and in the fall of the same year enrolled at



F. Miescher

Tübingen for chemical study. Wisely, he spent the first semester there, not in research, but in sharpening his tools in the general chemistry laboratory of Strecker. After acquiring some foundation in organic chemical technique, Miescher brought the problem of isolating the nuclear components to the laboratory of Hoppe-Seyler. The attitude of Hoppe-Seyler to this problem, judged by his later actions, must have been one of benevolent skepticism, but he allowed Miescher free rein to go ahead. As source material for this investigation, Miescher chose pus cells. The choice of this material was most probably due to the very large ratio of the nuclear to the total volume of lymphoid cells. The pus cells were obtained by extraction from used bandages discarded by the adjacent university clinics, and the hardihood necessary to work with such material is probably better imagined than described; indeed, in his first published description of this work, Miescher perhaps unnecessarily explains that those bandages which stank too much were not used.

The separation of the cells from the pus fluid was not easy, for most of the extracting solutions caused clumping and slime-formation. In a letter to His, dated February, 1869, Miescher described the first successful separation of the cells by employing sodium sulfate solutions, and added the line familiar to all protein chemists, "there is no more miserable task than to attempt a sharp separation of the proteins." From the cells so obtained, the nuclei were isolated by treating the former first with dilute acid, later with pepsin-hydrochloric acid, and then with ether. On shaking, the nuclei settled to the bottom of the flask and could be filtered off. Miescher was thus the first to recognize that the nucleus possessed a higher density than the rest of the cell, a fact that has since been amply confirmed by studies with the centrifuge. The nuclear material appeared to be a compound of unusual sort to which Miescher gave the name "nuclein," and which we would now call nucleoprotein. Characteristic of the compound was its ready solubility in soda and insolubility in dilute acids, as well as its high proportion of phosphorus in firm combination.[1]

This work set the pattern for the major part of Miescher's subsequent labors, and formed the basis of his often-expressed belief that the study of the chemical phenomena of the tissues would clarify many of the processes which were hitherto obscure or inaccessible to examination by the microscope. In a letter to His, written a few years before his death, Miescher expressed the hope that by the chemical separation and analysis of pathologically-altered tissues, particularly that of the nuclear components, information on such processes as inflammation and degeneration (cancer) could be obtained, and he concluded this letter with the well-known sentence, *"Das Mikroskop lasst einen, wie man am Ei sieht, gewiss oft im Stich."* In this sense, Miescher envisaged the field of pathological chemistry.[2]

Miescher completed his work in Hoppe-Seyler's laboratory in the fall of 1869, wrote up the results of this work, and gave the manuscript to Hoppe-

[1] Up to this time, organic phosphorus, with the exception of comparatively rare instances such as Liebig's inosinic acid, was observed only in lecithin. For a long period after Miescher's discovery of nuclein, later workers referred to compounds which contained organic phosphorus as nuclein or nuclein-bodies, sometimes as nucleoproteins, without relation to Miescher's original specific designation. The curious persistence of this error only ceased when the nature of the phosphorus-containing substances became clarified, but it has necessitated great care in the reading of the scientific literature of this period.

[2] As a commentary on Miescher's vision, it may be noted that the problem *par excellence* of pathologically-altered tissues, namely that of cancer, has been approached analytically by the chemist only within the past few years, and that on the whole the independent status of the chemist in the field of pathology is at present quite uncertain and controversial.

Seyler for publication in the latter's journal, then called the *Medizinische-chemische Untersuchungen.* Miescher himself then left for Leipzig to study physiology in the Institute of Carl Ludwig, then at the height of its fame. Miescher had no particular problem in mind when he went to Leipzig and his intention was simply to learn what was going on and to master certain of the techniques Ludwig offered him a problem on the bone marrow, but Miescher declined, believing the problem to be too complex. Also his own problems on histochemistry never left his thoughts. He was fascinated by the international character of Ludwig's laboratory and by the students who represented every famous school of physiology in Europe. Among his colleagues was the American, Bowditch, and "a Mohammedan from Cairo." In a letter to Hoppe-Seyler he states, "almost all present schools are represented by pupils or former assistants—Voit, Helmholtz, Dubois-Reymond, Kühne, Recklinghausen, Brücke, etc. Each one brings something with him, and even I, as an 'Absenker' from your laboratory, am able to give wise counsel on hemoglobin." Many conversations with the dynamic Ludwig and the beginnings of lifelong friendships with men like Boehm, Hüfner, and Schmiedeberg, made life pleasant during Miescher's stay in Leipzig.

OLD UNIVERSITY BUILDINGS AT BASEL, SWITZERLAND
RISE PROUDLY BESIDE THE RHINE HERE FRIEDRICH MIESCHER WAS PROFESSOR OF PHYSIOLOGY.

Miescher held Ludwig's personality and teaching ability in high regard, although he pointed out Ludwig's unwillingness to take unripe men and to build them into independent scientists. Ludwig was a great virtuoso, who enjoyed the awe of a crowd of students watching him work. In a letter to his parents, Miescher relates that all the work in Ludwig's Institute is solely his, and humorously describes how each student holds a towel or a rag at some piece of work over which Ludwig presides,

knows nothing of what is going on, and then to his astonishment finds sometime later a very fine paper in the literature under his (the student's) name alone. Ludwig followed Miescher's subsequent career with sympathy, and when Miescher lay finally on his deathbed, sent him the fine letter which included the following:

> Of course it is easier to preach patience than to practice it, and from my own experience I know what it is to give up well loved, hopeful work. Sad as it is, there remains to you the satisfaction to have completed immortal studies of which the main point has been the knowledge of the nucleus; and so as men work on the cell in the course of the following centuries, your name will be gratefully remembered as the pioneer of this field.

In the meantime, during Miescher's stay in Leipzig and after his return to Basel in the summer of 1870, no word had come from Hoppe-Seyler as to the fate of the manuscript on nuclein. Indeed, the fate of that manuscript was destined to form one of the curious episodes in the history of science. Hoppe-Seyler was frankly sceptical of the work and hesitated to publish it. To do him justice, he probably felt keenly his dual responsibility as editor and as chief of the laboratory in which the work was done. He therefore wanted to repeat the work, and at the same time to extend such a study to the nuclei of the avian and reptilian erythrocytes. Hoppe-Seyler explained his position in a note to Miescher and suggested that, if the latter was in a hurry to publish, he send a brief communication to *Pflugers Archives.* Miescher answered that he was quite willing to wait until Hoppe-Seyler was ready to publish the work, and causally added that he noticed that Hoppe had already inserted the description of the nuclein technique in the new edition of his book. Finally, the fourth volume of the *Medizinische-chemischen Untersuchungen,* published in 1871, carried Miescher's classic, "Über die Chemische Untersuchung von Eiterzellen," and in addition a paper by Plosz, "Über das Chemische Verhalten der Kerne der Vögel-und Schlangenblutkörper."

Hoppe-Seyler's attitude to Miescher's work was best expressed in the introduction to his own paper in this volume, in which he confessed himself at first doubtful of Miescher's results but later confirmed him personally at every point. The whole affair, which was conducted on a high level of courtesy on both sides, concluded thus handsomely, and in a letter afterwards to His, Miescher expressed his appreciation of his former teacher, and concluded with the generous statement that "Hoppe-Seyler is master of the entire field which encloses histology on the one side and pure chemistry on the other." In the extension of Miescher's work, Hoppe-Seyler had isolated nucleins from yeast and from other sources. Miescher felt somewhat concerned over the superficial resemblances between these nucleins and the nuclein which he had isolated from the pus cell, and in a brief note called "Nachträgliche Bemerkungen" he warned against taking pus cell nuclein as a model for all such compounds. Hoppe-Seyler declined to publish it, on what grounds is not clear. It is true that Miescher, although later work by others substantiated his thoughts on this point, adduced no experimental evidence at the time to indicate that the nucleins from different sources were not identical.

In 1871 Miescher became *privatdozent* in physiology in the university in Basel and for his *habilitationrede* he chose to discuss the work of the Leipzig school of Ludwig, chiefly in the field of the physiology of respiration. A year later he was appointed successor to His as professor of physiology in the same institution. Previous to this appointment His had taught both anatomy and physiology and it is easy to see that he simply invested his younger colleague and former pupil with the conduct of the

PROFESSOR MIESCHER'S LECTURE ROOM IN THE "VESALIANUM."

latter subject Miescher, although free to do his own work, was hampered by lack of space and equipment, and in one of his letters of this period expressed his yearning for the "fleshpots of the Tubingen laboratories" His work was performed in a small corner of the general chemistry laboratory, for he had none of his own; his analyses were carried out in the corridor of another building, and for assistance he had "one-fourth of an anatomy *diener* who also had to help the anatomists, the zoologists, and the pathologists" Miescher bore these difficulties not too nobly, nor very quietly, and made no effort to stifle his disappointment over the "most miserable conditions" and his misfortune to be so hampered at the "height of my powers" (he was then twenty-eight years old). Nevertheless his finest and most enduring work was performed under these conditions, as Pasteur's had been under similar circumstances in the École Normale; later, when both Miescher and Pasteur had comparatively palatial institutes built for them, their personal creative powers had waned.

When Miescher began his duties in Basel in 1871, His had been working for some time on the histology of the developing salmon egg The fishing industry was one of Basel's busiest, and the necessary material was readily obtained Miescher quickly observed that the salmon sperm was an excellent source of nuclear materials, and wrote enthusiastically to his Leipzig friend Boehm, "we have here within a few weeks time an enormous increase (in the sperm cell) of nuclear material which is formed within the cell at the expense of ? ?" In a later letter to Hoppe-Seyler, now at Strassburg as a by-product of the Franco-Prussian war, Miescher describes the fish spermatazoon as a model

of the nucleus of more complicated cells with an overwhelming proportion of nuclear mass Miescher threw himself into the work on sperm with ardor and energy, and in the spring of 1872 he notified the natural history society in Basel that he had found the isolated sperm heads to be a compound of nuclein of high molecular weight (now called nucleic acid) and a base standing between urea and proteins in complexity, which he called "protamine" The sperm head was largely a salt of nucleic acid and protamine which did not show the properties of a simple mixture of the two substances.

This paper of Miescher's, published in the sixth volume of the *Verhandlungen der naturforschenden Gesellschaft in Basel*, is a landmark in the history of biological science In the beginning of the paper Miescher pointed out that the testicles of salmon in March weigh on an average fifteen to twenty grams, whereas in November of the same year (the time of spawning) the average weight is three hundred to four hundred grams, and sometimes more He briefly speculated as to the source of this increase in weight The sperm head could be dissolved in strong salt solutions from which fibers precipitated on dilution with water [1] The nucleic acid could be separated from the protamine base by extraction of the defatted sperm with weak acid, whereby the base was removed and the acid left as the residue The former was purified as the platinum salt, the latter was purified by dissolving in weak alkali followed by precipitation with alcoholic acid.

[1] Fibrous precipitates obtained in this way from tissues were long studied by biologists, who generally mistakenly confused them with the myosin fibers of muscle In recent times, Bensley, and Mirsky and Pollister, reviving this method, observed that the material so obtained was largely composed of nucleic acid

THE "VESALIANUM," INSTITUTE OF ANATOMY AND PHYSIOLOGY, BASEL.

Miescher then went on to describe the sperm head as, "an insoluble, saltlike compound of a highly nitrogenous organic base with a phosphorus-rich, acidic nuclein (nucleic acid)." That nucleic acid was somewhat in excess within the sperm he could prove by adding free protamine to the latter and obtaining a new precipitate of an acid-protamine complex.

Miescher's insight into the properties of these components was profound; he did not view the sperm complex as a static but rather as a highly fluid system, the composition and properties of which varied markedly according to the conditions present. Toward the end of this classic paper he pointed out that sodium chloride, protamine, and nucleic acid formed a three-component, dynamic system, the equilibrium point of which was governed by the relative concentrations of each of the components as well as by the *Alkalescenz* (pH in modern terms)[4] The basic reason for these dynamic interchanges Miescher recognized in the polyvalent character of both nucleic acid and protamine and in the ionic dissociation of the salt.

The idea of a state of flux, of a dynamic interchange among the organic and inorganic components of the cell, was always strongly emphasized by Miescher. In a letter to His, dated May 1876, he discussed the equilibrium forces among the protoplasmic components, and included the following observations which are worth quoting:

> The thought always occurs to me that the proteins are really both strong acids and strong bases, which possess a neutral reaction only because of an inner neutralization. If one mixes sodium chloride with protein there must occur protein chloride, sodium proteinate, and protein-proteinate. Different proteins have different affinities, and even the insoluble proteins are not unreactive.

Thus was stated the amphoteric character of the proteins long before it was established by the work of Küster, Bjerrum, and the workers of the present day.

Ruefully, Miescher added that while he intuitively recognized the presence of equilibrium forces he lacked the ability to formulate them—"lacking in the knowledge (of these forces) which is of the magnitude of the Gotthardt Tunnel, I can only find myself a mouse-hole." Nevertheless, nowhere has biochemical dynamism in the form of protein reactivity been better expressed.

The work on the ripe salmon sperm was subsequently extended to include the sperm of the frog, bull, and carp Although nucleic acid could be readily isolated from the latter sources, no protamine was evident. Protamine was likewise absent from the unripe salmon testicles. Combined with the nucleic acid in these materials was, instead, a sulfur-containing protein of considerably greater complexity than protamine. Miescher was puzzled over these findings, and in a letter to Boehm dated January, 1873, declared that the presence of protamine in the salmon sperm was a "miserable, special case," and suggested that the "pompous designation (of protamine) be immediately buried." The unique character of the protamines and their ontogenesis was recognized later by Kossel, partly on the basis of Miescher's work on the development of the salmon gonads and partly from his own fine analytical data on the constituents of the protamines.

But most of Miescher's attention was lavished on the preparation of nucleic acid from various sources. Recognizing the lability of this material, he spared no effort to obtain preparations in as unaltered a form as possible. In a posthumous paper edited by Schmiedeberg he states that all work was performed in a room at two to three degrees centigrade or less. His working day, he described in a letter to Boehm: "When nucleic acid is to be prepared I go at five o'clock in the morning to the labora-

[4] Confirmed in all details subsequently by Hammarsten and his colleagues in Stockholm.

tory and work in an unheated room. No solution can stand for more than five minutes, no precipitate more than one hour before being placed under absolute alcohol. Often it goes on until late in the night. Only in this way do I finally get products of constant phosphorus proportion." Miescher's analyses of his preparations, as Levene and Bass have pointed out, compare favorably with the best of the modern analyses of nucleic acid. Yet Miescher, by temperament, was not an analyst. Over and over again he rather mournfully described the effort devoted to his analyses as *Fabrikarbeit* and as an activity which "prospers best when least accompanied by imagination." Nevertheless he appreciated the value of such effort and in a letter to Boehm remarked that "always I ask myself if histochemistry could only be conducted otherwise (without analysis), and always I return to my phosphorus, fat, and other determinations, as a necessary control and assurance against disappointments with the work with the microscope." Working under such stringent conditions with so little assistance, his frequently expressed impatience is easy to understand—"if one could only live for a couple of hundred years and not have a pack of hounds on his tail, it would be a pleasure to work on these problems, but *vita brevis, ars longa*. . . ."

Possibly, in part as a relief from the exacting work on the isolation of the nucleic acids, and in part as a result of the stimulation of His, Miescher undertook, about 1875, the problem of studying the transformation of the salmon tissues during the period of gonadal development. It was long known to fishermen that the salmon did not eat as long as they were in fresh water. As a well-nourished animal with undeveloped gonads, the salmon leaves the sea, enters the Rhine at Holland, and, swimming upstream, remains for many months during the summer and early fall in the upper, sweet-water reaches of the river. During this period the sexual organs mature at the expense of the rest of the fish's body. After spawning, the hungry fish rush back to the sea. During the stay of the fish in sweet water there is evidently a chemical breakdown of the tissues, a transfer of the split products to the site of the gonads, and a synthesis at the latter site. With great energy, Miescher studied thousands of salmon (readily available in the great Rhine-port of Basel), weighed the muscles, livers, spleens, blood, and gonads, and studied the last mentioned both histologically and chemically throughout the developmental stages. Only part of this gigantic work was published during Miescher's lifetime; the remainder was collected and edited later by his friend Schmiedeberg.[5] In the work published in 1880, Miescher described the balance of protein, fat and phosphorus in the sexually-developing salmon, and showed that it is the musculature of the fish which supplies the material subsequently synthesized in the gonads. Those muscles most affected possess, during this season, the poorest blood supply, and Miescher expressed the belief that the "liquidation" of the musculature (lysis) was facilitated by comparatively anaerobic conditions. For synthesis of tissue proteins, on the other hand, a rich source of oxygen was necessary. The concept that the equilibrium between lytic and synthetic processes was regulated fundamentally by the tension of the available oxygen was frequently emphasized by Miescher throughout this work, and suggested a fruitful approach to many problems in physiology.

Engrossed as Miescher was at this period (1876) in the work on the salmon and in the conscientious conduct of his teaching duties, he received to his dismay an order from the Swiss govern-

[5] *Statistische und biologische Beiträge zur Kenntniss vom Leben des Rheinlachses in Süsswasser.*

ment to investigate and prepare a report on the nutrition of the inmates of the Swiss prisons. Miescher frequently called this task the most troublesome and thankless of his life. He realized that little could be done in view of the inadequate knowledge of nutrition at the time, and that which he tried to do only embroiled him in profitless controversy both with the authorities and with the commercial companies. He bitterly attacked the diversion of fresh milk from the needs of growing children and nursing mothers to the manufacture of cheese for export, and despite his official position did not hesitate to write indignant letters to the daily press in support of his views. Nevertheless, to his private consternation, he was recognized as the Swiss authority on nutrition, and wryly described to His his status as "the watchdog over the stomachs of three million fellow countrymen." Perhaps Miescher's most important contribution in this field was his recognition of the indispensable role of the proteins, particularly the animal proteins, in human nutrition.

At the close of his great work on the salmon, about 1882, the government constructed for him a fine research institute in Basel which was opened with much ceremony in 1885 and later nicknamed the "Vesalianum." But the creative period of his life was over, and he suffered from fits of lassitude and depression, forerunners of the tubercular disease to which he was to succumb. The long days and nights spent over many years in rooms around zero degrees Centigrade had begun to exact their toll. Depressed by the waning of his strength he wrote with wry humor to Boehm, "the basic feeling of my life is that uncomfortable sensation of a man who has lost the buttons of his suspenders" and, "every night I go to bed with the feeling of a schoolboy who has not learned his lesson for the day." "I know better than anyone else," he wrote to His, "that my work is only the preliminary study to a future Histochemistry." All this came hard to Miescher, for his was the intense belief that creation was the first law of the spirit. "One should always do something by oneself," he wrote to an old friend, "no matter how small." During the last few years of his life, he devoted his remaining strength to the stimulation of the interest of younger men in the field of physiology. "A professor without young collaborators," he wrote, "is *'nur so ein verstümmelte Weidenstrunk.'*" His teaching was cast in a stern mold, and appealed only to his better students. Jaquet, one of his assistants, quotes Miescher as saying, "hard work develops the investigator's talents, and he who has not learned to surmount difficulties in his youth cannot later cope with them." The research work in the institute during this period was carried on almost exclusively by Miescher's pupils and was concerned with the physiology of respiration. This study took two forms, the development of new apparatus for measuring blood gases, and field work on the blood components at high altitudes. The latter approach revealed that the blood count of individuals rose as they ascended into higher altitudes and decreased as they descended.

Miescher died in 1895. His life's credo is best expressed in a letter written to Boehm in 1871: "I believe that in the organic world each complicated case is built on simpler things, and these in turn on still simpler things . . . each case must be reduced to its simplest terms " This belief, carried into practice, was the basis of the founding of a new branch of science.

ANCESTORLESS MAN: THE ANTHROPOLOGICAL DILEMMA

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CONFRONTING me is one of the new ponderous volumes which it is now the fashion for sociologists to issue in the field of general sociology. As a teacher of anthropology and sociology, I am critical of the genealogical trees built by scientists purporting to show the evolution of man from pre-human ancestors through successively ascending human levels.

The tree in this book formally repeats the patterns of genealogical trees which were begun last century. The present book does not prove nor even pertinently illustrate the fact of evolution It is all branches and terminal twigs which have no fibers running through the trunk specifically connecting with definite ancestral forms. So men, those of the present and of lower levels, stand ancestorless. The accompanying interpretative explanations are quite as vacuous. This is a fair sample of the genealogical trees now appearing in sociological, anthropological and biological works.

It is evident that anthropologists assume and profess to be evolutionists. They probably would resent the suggestion that they are dogmatists in the biological field, yet such appears to be the case regarding the subject under discussion. By their works ye shall know them, and it is by their work products in this particular field of evolution that they are now to be judged. Their genealogical trees purporting to show the evolution of man should satisfy theological fundamentalists who reject the idea of such evolution. In fact they are empty forms which consist of nothing but assumed roots, trunk, many limbs which grow in number through the years, and human twigs terminating the trunk which are supposed to connect with the assumed roots. Now a tree that is constituted wholly of limbs does not tell us much Limbs below do not beget the limbs above them. They are not ancestral to them, only cousins to what is above them. The anthropoid limbs on these genealogical trees above the roots are the various living apes: gibbon, orang-utan, gorilla, chimpanzee; and the human levels: Pithecanthropus, Sinanthropus, Heidelberg, Eoanthropus, and Neanderthal. Present races are the twigs at the top. The trunk is empty of content from twigs to roots, which represent an extinct ape. Living apes and the various levels of men between apes and present men are asserted to be too different from recent man to be his ancestor. So present man's lineal ancestor is supposed to be some Miocene pithecan who lived some fifteen million years ago and which must have differed from the recent humans tremendously more than do the intervening forms The present writer is an evolutionist and believes he may perform a needed scientific service by calling attention to some of the inconsistencies in the situation.

Anthropologists share genealogical conservatism along with biologists generally. Biologists are, of course, confessedly evolutionists, but it is really remarkable how little evidence they admit in support of their position. This is so true that a scientific writer published an article a few years ago in which he took the position that since evidence linking modern species with the ultimate primal form is lacking, it is necessary to think that they have been ex-

tant since the earliest phyla appeared. Further, since there are no evidenced connecting links between the linear series of forms developing from those original phyla we must think of evolution as only meaning the development from level to level of forms which took place within those linear series Finally, since even within those linear series, as is found in the case of dog and anthropoids, there is an absence of small gradual variations leading from variety to variety, it is necessary to think the gaps were bridged by great mutations.

The conventional genealogical conception originated out of the discussions of Darwin, Wallace, Haeckel, Vogt, and others in the first part of the last half of the last century. It was elaborated and more fairly established by Broca, Kollman, De Quaterfages and others of the eighties and nineties of that century. As we read about how they reached their conclusions, we are impressed by the fact that bold guesses and generalizations were made which were supported by a paucity of water-tight proof From time to time as new finds of pithecans and humans have been made, their types have been added as limbs on the genealogical tree at the supposed appropriate point. This pattern had become traditional by the beginning of this century. Now when genealogical trees are constructed they are apt to follow this traditional copy. We will note how these gaps are treated by some recent anthropological authorities.

A discussion of the origin and evolution of man must center in the concept, man, as distinguished from concepts of other forms of life. There are only a few certain criteria of man. Where these are present in an organism it must be pronounced human. Where they are absent, the organism must be regarded as non-human. These criteria are: rectilinear erectness, non-opposable great toe (a walking, not climbing, toe), flat footedness, general hairlessness of skin covering, comparatively great brain capacity. All humans possess all of these traits, while they are absent in all simians.

The evolution of man embraces three large general levels of organic forms, and of course many smaller ones. It will prove illuminating to examine the three large gradations for the purpose of observing the hiatus between them left by professional and authoritative anthropological writers. These gaps exist between man's sub-human ancestor and primal man, between primal man and Neanderthal man, and between Neanderthal man and present man, ***Homo** recens*, or *sapiens*.

There are three forms of living great apes which stand closest to man in anatomical respects: gorilla, chimpanzee, orang-utan. They are humanoid in most essential traits. They deviate from recent humans in size of brain, in being quadrumana for locomoting purposes, in being hairy, in being heavily prognathic, in having beetling brow ridges, and in having a climbing foot with opposable big toe rather than a walking foot. Their average brain capacities range from some 300 to some 550 cubic centimeters. Probably this is the most important difference from man as it limits simian level of intelligence to one of childish humans. The recorded cranial capacity of the modern European type of man ranges from 880 to over 1800 cubic centimeters. The average may be set at 1550. If we regard the average brain capacity of great apes as 400 and give that a value of 100, then the average brain capacity of modern European types possesses a value of 386, almost four times as great. It would require an unthinkable mutation to step up to the higher form of anthropoid life.

There is large agreement among recent anthropologists to the effect that man's direct ancestor was an extinct

ape. It is apparently the method of evolution they espouse (more or less conventionally) which leads them to hold that living apes differentiated too recently to give time for the evolution of humans from them. Anatomically, apes are very similar to humans. Professor Hooton in his *Up From the Ape* abundantly shows this. They are thousands of times more similar than dissimilar They are so much like us that we have scientific difficulty in assigning them anything like a remote classification The general fashion has been to erect living apes into one family and human beings into another. But Professor H. H Wilder says that, anatomically, this is not permissible. Since they are too much like humans, he includes all living apes and man in one family, *hominidae,* and places under this three sub-families: gibbon, the great apes (gorilla, chimpanzee, orang-utan), and man. In general it may be said that living apes are so much like the fossil apes that lived in Miocene times some fifteen or twenty million years ago, and which are supposed to be ancestral to both living apes and man, that what is said of the former may also be attributed to the latter.

There is an anthropological dogma that some type of Dryopithecus, which lived far down in Miocene times, is the most promising candidate for the position of man's simian ancestor. This type of ape was widely distributed in Asia, Europe and Africa. Recently it has been found to have possessed two distinctively human skeletal traits which other ancient simians did not have. One was the *linea aspera* of the femur bone which experts say is a certain indication that the body occupied an erect position; for it is a vertical projection on the posterior side of the femur to which the extensor muscle from hips and back attaches itself, thus making possible the erect attitude. Only erect animals have this appendage on the femur. The other characteristic was pentacuspid molar teeth. In his *Origin and Evolution of Human Dentition,* Professor W. K. Gregory demonstrates our dental lineage. More than almost any other organ, teeth hold their traits through millions of years. Man's teeth, along with those of other primates, are pentacuspid and are thus differentiated from those of other mammals. So here was Dryopithecus, an ancient Miocene simian with pentacuspid teeth, a definite primate mark Thus Dryopithecus qualifies in two definite respects to serve as man's remote pithecan ancestor. But anthropologists and biologists furnish us with no series of specific connecting links with that ancient pithecan, and they reject as spurious the only series we do possess. These are now to be discussed.

The earliest recorded representatives of the human level are Java Man (*Pithecanthropus erectus*) and Pekin Man (*Sinanthropus pekinensis*). The first skeletal remains of the former were unearthed in central Java by DuBois in the seventies of last century and those of the latter in limestone caves near Pekin since 1927 by Davidson Black and his scientific associates The former had a brain capacity of about 900 cubic centimeters, that of the latter being slightly greater. The straight, slender femur of the former with its *linea aspera* calls for a walking, upright individual, the few teeth found are humanoid, and the brain capacity is a half larger than that of the largest pithecan skull ever measured. Skulls, teeth, and bones of wrists and knuckles of the latter denote an erect human being. Some authorities rate them as of different species or types; others think they are specimens of the same species. Since their differences are much less than those which obtain among modern men, even among those of the so-called "white race," it seems superficial to try to regard them as two species or varieties.

Before discussing the relation of this human type to apes and to other human levels, we should allude to several representatives of what is sometimes called the Ape Man of South Africa. The brain capacity is that of the largest gorilla brain, the teeth are human-like, and leg bones and head balance indicate an organism that walked upright. It may be a link between pithecoids and humans

Genealogical tree builders show what they think of the relationship between *Homo recens* (modern man) and Java-Pekin Man by the position they give the latter on that tree. He is placed far down the trunk as a very lowly limb, thus indicating he is not in our direct ancestry but is a distantly related cousin or uncle. We will allow two current representative anthropologists explain why this position is assigned. Here is Dr. J. H. McGregor speaking:

> At the present day, in the light of later discoveries of early Pleistocene man, no one believes that Pithecanthropus is a "missing link" in quite the same sense that Dr. DuBois first considered it, but still in a way it is a "link" in that it is more apelike as regards the skull and brain than any other human family, it is certainly the lowest in brain development and, by inference, in mentality and cultural capacity. . . . Pithecanthropus may not be directly ancestral to any other human type, but it may mark instead the end of its particular branch of the family. Even in this case it would be vastly important as representing at least a collateral ancestor—a great uncle rather than a grandfather.

The position of Professor Hooton is very similar.

> It really matters very little whether we consider Pithecanthropus a giant ape belonging to an extinct branch nearer to the human line than any other anthropoid stock, or whether we decide that the Java primate is an early and obsolete humanoid form which diverged from the main stem of development before the evolution of essentially human types. It is of small moment whether we are to call him "Grandfather" or "Grand Uncle." It seems improbable that the 500,000 (many geologists say 1,000,000) years which have elapsed since Pithecanthropus was smothered in ashes, have witnessed the evolution of his progeny into modern man. Such time is too short for so rapid a development.

So it appears to be "scientific" to guess him off as a trial evolutionary balloon which began back in Pliocene times and finished its course in late Pliocene or early Pleistocene.

This Java-Pekin kind of human is thus put out of the running for being our ancestor because to it is imputed considerable or great anatomical differences. The chief differences they see are smallness of brain, heavy torus (eyebrow ridge), low retreating forehead, and more or less pronounced prognathism. The most telling differential is doubtless that of brain size. Now, I am not seeking to prove that Java-Pekin is our immediate ancestor but only attempting to make an approach for a fair scientific appraisal. In order to accomplish this I will indicate the range of differences in cranial capacity obtaining within the modern race itself and show that it does not exceed that existing between the latter and Java-Pekin Man.

The smallest cranial capacity of an adult modern is that of a Tyrolese woman that registered only 800 cubic centimeters. Comparable with that was the capacity of the Australian female of 930 and of the Dravidian Bheel of 940 cubic centimeters. The greatest capacity stands at 1800 cubic centimeters or more, let us say 1800 for convenience. Now if we give the Tyrolese brain capacity a value of 100, that of average European brain capacity becomes 204. The latter capacity is more than twice that of the former. In like manner let us assign a value of 100 to the average cranial capacity of Java-Pekin Man, 950 cubic centimeters. Then the least modern cranial capacity, 880, possesses a comparative value of 92.5, very much smaller rather than tremendously larger. Then, if we compare the brain capacity of Java-Pekin with the average brain

capacity of modern Europeans, 1550, we secure this startling result. Giving the former a value of 100, the latter has that of only 163. This is a far smaller range of cranial capacity than occurs within *Homo recens*. The average European brain is only 63 per cent. greater than that of Java-Pekin, while the greatest brain capacity of modern man is 102 per cent. greater than that of the smallest capacity within that group Anthropologists place Java-Pekin low down in the genealogical tree as a mere limb. In terms of brain capacity where would an authoritative anthropologist place the Tyrolese woman or the Dravidian Bheel? They assign them a position among the tipmost twigs of the genealogical tree because they happen to belong among moderns. Judged by brain capacity alone they could not qualify for a place among our ancestors on the genealogical tree. They could only be low down limbs on that tree.

Likewise, it could be shown that in respect to other physical traits modern man exhibits as great intra-human differences as those between Java-Pekin Man and apes, between Java-Pekin and Neanderthal Man, and between the latter and present man, *Homo recens*

Anthropologists usually dispose of Neanderthal Man as another evolutionary balloon which nature sent up in its effort to evolve full-fledged human beings. The Neanderthalers lived in Europe during the last third of the ice age. This developmental strain, some suggest, possibly may have passed through the Heidelberg level in its upward course, as jaws and teeth of Neanderthal and Heidelberg somewhat resemble. But this attempt to realize full-orbed man ended abortively, according to conservative and traditional anthropologists, never having arrived at first base as Cro-Magnon Man. So this second great level of man is not honored as being ancestral to modern man, but finds its place as uncle or cousin among other branches of the genealogical tree. It was suggested previously that a branch is not ancestral to other branches above or to the tipmost twigs of the tree.

The first specimen of Neanderthal Man was found in a limestone cave in the Neander river valley of Germany near Dusseldorf in 1885, hence the name, Neanderthal. Since then the remains of some twenty Neanderthalic individuals have been unearthed The greatest density of distribution is found in France and Belgium. From there the finds spread eastward through Europe and southwestern Asia, and possibly as far eastward as China Hrdlicka would class Pekin Man among Neanderthaloids. It is patent that this kind of human is well authenticated Liberal estimates set the beginning of this type in Europe at about 150,000 years ago during early or middle third interglacial. Conservative estimates, based on stratigraphical rather than radioactive methods of computing geological time, set the further time limit at 75,000 years ago. The last of the more extreme Neanderthalers ceased to exist (so far as finds go) about 25,000 years ago, during the latter part of the last great ice sheet. The time span of the pronounced specimens of this people in Europe was thus anywhere from 50,000 to 125,000 years.

Anthropologists usually describe this type of man according to the physical traits of the more extreme specimens rather than by those of average individuals, the proper scientific mode of identifying species and varieties. So described, the more outstanding Neanderthal traits are: Large torus (eyebrow ridge), low retreating forehead, relative chinlessness, prognathism, low stature, massive chest and shoulders, forward flex of knee and stoop of head and shoulders (greatly exaggerated), and undeveloped heel bone (calcaneum). In average Neanderthalers these traits are

reduced and in the variants toward the other extreme (those with less and less) they all but disappear. So there exists a range of variation in these traits from glaringly obtrusive on the one side to feeble manifestation on the other.

There is need for emphasizing the fact that while one or more Neanderthalers glaringly manifested several of these characteristics, probably no one individual had them all in a pronounced way and certainly not all the traits pertain to all individuals of that class. The score of individuals which make up this group were more Neanderthal generally than are members of any present racial stock, but to the latter belong many individuals which in one way or another are more Neanderthal than were the Neanderthals generally or than most Neanderthals particularly.

The difference between cranial capacity of Neanderthal and *Homo recens* is much less than the range of difference exitsing within either group. We have seen that the mean cranial capacity of Europeans is 1550. That of four Neanderthalers (Neanderthal, male, 1400; La Chapelle aux-Saintes, male, 1600; Gibraltar, female, 1300; LaQunia, female, 1370) is 1418. If we allow a value of 100 to the Gibraltar skull, La Chapelle has a value of 122, only 22 per cent. greater. This is relatively insignificant as compared with the 102 per cent. difference existing between the smallest and approximately largest modern brain. It is also much less than that found between smallest (1100 cc.) and largest (1600 cc.) Neanderthal cranial capacity. The latter has a value of 145 in comparison with the former, nearly a half greater. The average European brain is only 14 per cent. larger than the average Neanderthal brain. The intra-Neanderthal differential cranial capacity is three times and the intra-*Homo recens* differential capacity is over seven times greater than is the difference between the average cranial capacity of Neanderthal and *Homo recens*. Scientists have no justification on such grounds for rejecting Neanderthal as ancestral to modern man.

Conservative anthropologists generally reject Neanderthal Man as the forebear of Cro-Magnon and recent man but they do not tell us who our ancestor was. The traditional position is that Neanderthal Man entered Europe catastrophically and disappeared catastrophically. He pushed into that continent suddenly, it is held, since there was no anatomical premonition in other human types, and since his flaked stone implements were great mutations and not introduced by evolutionary stages from preceding chipped stone implements of Europe. Then it is maintained that his type of anatomical form disappeared suddenly without symptoms of evolution into later forms and that his culture, flaked stone implements, as suddenly gave way to the Aurignacian chipped implements. But Dr. Hrdlicka takes an evolutionary point of view of the appearance and disappearance of Neanderthal. He develops his ideas in a telling paper in the annual Smithsonian Report of 1928. His strongest evidence comes from the side of culture rather than from anatomy. He shows that there was a gradual evolution of stone implements from the preceding Acheulian chipped kind to the flaked implements of Neanderthal. He cites expert archeologists who work European stations to the effect that no one can make a definite line of demarcation between pre-Neanderthal and Neanderthal implements, nor between the latter and Aurignacian artifacts. His study of the foods of pre-Neanderthal and Neanderthal people indicate that there was no great divergence in kinds and forms of food. A compilation of data on dwellings shows that here had been a gradual trend away from open living sites to stone caverns before Neanderthal, that Neanderthal people continued the devel-

opment trend toward caves, and that early Aurignacian (Cro-Magnon) men continued the line of development. Dr. Hrdlicka visited all the museums of Europe and measured their Neanderthal skeletal remains. He concluded that, while there is a type of skeleton which may be recognized as Neanderthal, there is wide variation in the type which manifests itself in nearly every skeletal organ. He thinks that this variability foreshadows an evolution into a later form. Consequently Hrdlicka is an evolutionist regarding the origin and the "disappearance" of Neanderthal man. He maintains that Neanderthal man evolved into Cro-Magnon man and that the latter evolved from and out of the former. So we have at least one authoritative physical anthropologist who traces the descent of recent man from Neanderthal.

It is interesting to compare the position of such an ardent evolutionist as the author of *Up From the Ape* with that of Hrdlicka. Professor Hooton, in one passage, is certain that Neanderthal man utterly and suddenly disappeared from Europe. This event took place "sometime after the maximum of the last glacial advance." Ignoring the work of Hrdlicka, he asserts that his culture in the caves of Europe was replaced by one that was "quite different," that of the Aurignacian people. It is "inconceivable that they [the latter] are the descendents of Neanderthal man since there is little or no transition between the types." So Neanderthal man is relegated to the place of limb on our genealogical tree.

Dr. Hrdlicka recognizes that the Neanderthal type of man often occurs among European peoples in Europe and elsewhere. To him this is an evidence of the descent of present man, including Cro-Magnon, from Neanderthal. Professor Hooton recognizes this fact, too, but thinks it may be explained in some one of three ways: (1) Chance variation. But the cases are too numerous to be so explained. (2) "Evolution of modern man from a Neanderthaloid ancestor." But such an ancestor would differ from *Homo recens* more than does Neanderthal. It is easier to think of our evolution from Neanderthal than from a more primal and divergent type. (3) Such reappearances may be the "result of a hybridization of Neanderthaloids with some modern form of man." Professor Hooton favors this choice which might seem to recognize continuation as an evolutionary factor. One might expect that if there were types of modern men coexistent and in contact with Neanderthaloids, miscegenation would occur and that various kinds of progeny would ensue, some of which most certainly would be Neanderthaloid. The known record of racial evolution is characterized by intermixture and miscegenation of racial strains, so much so that there are no "pure races," polyracism is universal, and the recurrence of former racial types is likely everywhere. Such mixture is part of "racial evolution," which is a way of saying that it is a mode of the evolution of Neanderthal man into present-day man. So Professor Hooton unwittingly really seems to make a place for the evolution of Neanderthal into modern man. It is interesting to note that current anthropologists are curiously reticent about mentioning Dr. Hrdlicka's 1928 paper on Neanderthal.

Professor Hooton's contention that Neanderthal man could not evolve into Cro-Magnon man because the latter is a definitely different and advanced type loses some of its strength in view of what he says about Cro-Magnon. He contends that Cro-Magnon people were too variable to constitute a "racial type." He says that that so-called race does not possess "a single feature" which does not have "wide inter-racial distribution." The "so-called Cro-Magnon race

is nothing other than a hybrid type resulting" from an admixture of dolichocephalic (lond-headed) and brachycephalic (broad-headed) peoples If Professor Hooton is correct, we have to conclude that Neanderthal man had nothing definite in the way of a Cro-Magnon race to evolve into. And Dr. Hrdlicka tells us that Neanderthal was a greatly variable type Hence, we conclude that since the first *Homo recens* was so variable and since Neanderthal man was so variable, since there was no consistent racial type in either case, the idea of evolution of the one into the other does not seem impossible.

In view of the position of anthropologists that Neanderthal, Eoanthropus, Heidelbergensis, and Pithecanthropus can not be in our ancestral line because of considerable differences in anatomical structure, the question arises as to what gradation of difference they *would* accept. How could any essential structural difference whatever be accepted? Just what angle of deviation from spinal erectness will be admissible as being within the range of human kinship? What maximum degree of differential of knee tip, of pelvic deviation, of astrigulus divergence, of cranial capacity, of prognathism will be acceptable? We should be informed regarding the admissible degree of organic variation, but that matter is never explicitly discussed.

The conception of the evolutionary origin of man should be formulated in light of the great variability obtaining among men today. Racially humans are the so-called "white," "black," and "yellow" races, three or four great general racial types, which in turn differentiate into multitudinous racial and subracial kinds. Within each race and subrace exist very numerous and wide variations. The estimated number of races varies from three or four to thirty or forty, depending upon the criteria set up by classifiers. As an example, one of our leading anthropologists today, Professor Hooton, breaks present mankind down into thirteen races and fifteen sub-races, a total of twenty-eight. The mongoloid division is the only one he does not divide into races and sub-races. Deniker (1913) established twenty-nine racial types.

In order to glimpse this variability that exists, let us inspect one of the "great divisions of mankind, the so-called white race," in respect to a few of the physical traits which are regarded as criteria of race. It is called the "white race," but note its color variations. Its color graduates all the way from the lightest white, as seen in some Nordics, to olive and brown, as manifested among Berbers and Arabs About the best that can be said for the white race being white is that its color average is somewhat lighter than that of other races. Some individuals of certain other racial groups are whiter than some individuals of the so-called "white race."

The form of head is so divergent among "whites" that we cannot recognize it as a criterion at all of membership in the white race. The range of cephalic index (the per cent. horizontal head width is of horizontal head length) is from extreme dolichocephalism (long-headedness) to extreme brachycephalism (broad-headedness). We are not able to say definitely that the white race is more dolichocephalic than other races. And what is said about head form is about as true of stature Probably if we had the average height of all "whites," "blacks" and "yellows," the white average would be a little greater than that of either of the other groups. Nevertheless some of the tallest men on earth are found among the Soudan Negroes. The Akka Negrilloes are the shortest people with an average height of 54 inches, but Scandinavian Lapps are short whites, having an average stature of only 60 inches. The range of color of eyes

among whites runs from very light blue to lustrous black. The hair of whites varies in linear form from almost straight and lank to very curly, almost frizzy, so that the white race shares the forms of its hair with other races. Only one race, the Negroid, has a monopoly on any one form of hair, kinky hair Kinkiness is about the only certain criterion of race, and kinky hair is the only kind of hair "pure" whites do not have Caucasoid noses vary from low and broad to high and narrow. On the average, the white nose is a little higher and thinner than that of any other racial division, but it has no monopoly on most forms of the nasal appendage In contour of face, no race has a sole claim on orthognathism (straight alignment from forehead to chin) or prognathism (projection forward of jaws, especially at level of teeth). All we can truthfully assert is that probably the average of white faces is somewhat more orthognathic than are those of non-white groups. Nor is there anything peculiar to whites in bodily posture, members of other races being as rectilinearly upright as they.

What obtains among whites regarding variability in physical traits also is found among other types of mankind The variability is so great that as a consequence it is next to impossible to classify mankind into hard and fast racial types. The distance in range of variability between the extremes respecting these racial traits within *Homo recens* in most cases is greater than that obtaining between the averages of the various evolutionary levels of mankind

Some of the anthropological rulings against kinship descent and for establishment of different types because of seemingly not very great skeletal differences are patently untenable. As a matter of fact, we are all the time surrounded by persons whom we assign to one or another race amongst which there are far greater differences in structural build than there are between Java Man and Pekin Man, or between Neanderthal and modern man. The writer has been measuring students for many years and has collected data on head and stature measurements, color of skin, hair, and eyes, gnathic angle, form of hair, etc., of hundreds of individuals. His residential state has one of the largest Scandinavian populations proportionally of any state Nearly half the students are of that stock Yet within this group are found startling differences. Skin, hair, and eye color range from lightest light to almost darkest dark. Hair form varies from almost straight and lank to exceedingly curly, almost frizzy. Stature runs from short to very tall and build from stocky to slim The fluctuations of the cephalic index are extreme, ranging from 70 or less up to 100. Brain capacity varies from an approximate 1200 to 1700 cubic centimeters and over. Within the compass of the same cephalic index, crania present violently different contours, some full where others are scant, high, medium, and low. During 1941–42, among those studied were two brothers. In complexion, color of eyes, and in color and form of hair, they were fairly similar, but in cephalic index they stood far apart; that of one being 79 and that of the other 100. In stature, one was small and slight and the other was tall and robust. Some of the differences between Java Man and Pekin Man almost pale into insignificance in comparison with those which obtain within this Scandinavian stock. Could the skeletal remains of these students be placed clandestinely before the anthropologists who class Pithecanthropus and Sinanthropus as distinctive types, they could as consistently establish a half dozen or more racial types from them.

Within this Scandinavian stock is a man who is often referred to as the "Gorilla Man." The writer desired to see him. Finally the occasion presented

itself at a public gathering. From the description that had been given, his identity was at once revealed. But instead of being a gorilla man, he was a Neanderthal man. In most respects he was a good replica of some artist's reproduction of Neanderthal Man from data furnished by the anatomist. Here may have been a true descendent of traditional Neanderthal man stalking the earth today. Facial form, superciliary ridges, head build, posture of head on shoulder, forward stoop of massive shoulders, were of that description. Also within this Scandinavian stock occur many replicas of Cro-Magnon as traditionally described. The Norwegian stock, particularly, presents frequent examples of this conventionally typified man. Every considerable gathering of persons presents the same wide contrasts in anatomical traits. The riddle is how we come to consider them being racially alike at all rather than why we do not assign them to many different racial types.

The traditionally conservative attitude of anthropologists regarding our ancestry may be partly explained by their view of evolutionary methods. To think according to one supposed method of evolution might lead to conservatism, while a recognition of the operation of the other method would doubtless cultivate liberalism. It is interesting to note that anthropologists do not trouble to discuss methods of evolution, evidently regarding such matters as irrelevant or as having been settled by Charles Darwin.

It seems that most of our scientific thinking in the biological field regarding evolutionary development views evolution as natural selection of succeeding generations from a multitude of slightly varying forms. According to this mode, it might require millions of years for a series of slightly but gradually differing forms to grade upward into a new species. If the intervening gradient forms between species were not in some way preserved, there would be no record of the process and the connecting "missing links" between species would be lacking. There are not many cases where the record of gradual evolution has been as well preserved in nature as in the case of the horse, and even there wide genetic gaps appear. But it is one thing to hold that evolution of species has taken place in spite of the fact that the in-between links are missing and another to say that this species or form has not developed from that, no matter how much it seems such evolution must have taken place, because there is no step-by-step evidence of the fact. Thinking in this fashion, one is able to see how it is possible that "evolutionary anthropologists" build genealogical trees supposed to give the origin and development of man that consists of nothing but trunk and limbs with modern men perched as twigs at the top without any direct ancestors.

A widely different view of evolution makes room for the admission of large mutations, or variations from the preceding generation, in the developmental process. De Vries saw his primrose which he had watched for years all at once bear new species of flowers, the proof that they were new species consisting in the fact that they bred true to form without reversion to the old pattern of flowers. Clark, previously quoted, states that we find no transition links between the fundamental varieties of our dogs, although we know they have developed from one or a very few original types during their association with man. We can accept it as a fact (which Charles Darwin recognized) that large mutations, or leaps, in the form of organisms do occur among both plants and animals. By this means, some form of animal life may develop a new species of its kind during the span of one generation, whereas by the former method

discussed that result might require millions of years. By this means of mutation it is conceivable that some such pithecan form as Dryopithecus gave rise to the man-like ape, *Australopithecus africanus;* that that form at some time issued forth into some such primal human form as the ape-like man, Pithecanthropus or Sinanthropus; that from this beginning human sprang higher transitional humans, such as Heidelbergensis; that this level mutated into Neanderthal; and that finally Cro-Magnon was a mutation from Neanderthal. This mode of thinking is certainly as scientifically consistent as the other traditionally conservative one; and it has the advantage of accounting for man and for present men in terms of definite genealogical ancestry. Instead of standing forever as cousin or uncle or grandfather limbs on the genealogical tree, these enumerated beings would serve as ancestral forms linking us back through the various human levels to the pithecan strain from which humans and other anthropoids derived. Only by some such mode of thinking as this can the anthropological dilemma be solved and the puzzle of ancestorless man be replaced by scientifically derived genealogical forebears.

It is not necessary to think that a mutation of all anatomical features took place at one great leap; that conventionalized Neanderthal Man with all his anatomical peculiarities all at once dropped those features and mutated into the conventionalized Cro-Magnon Man. What would happen is a paring down of the most glaring features of the more subdued type of individuals and the consequent production of progeny which would approximate the Cro-Magnon variants nearest to the Neanderthalers. Such a transitional mutation would not be unthinkably pronounced.

The causes of mutations and variations may inhere in organic life or may be found in external conditions. The doctrines concerning small continuous variations are that they are inherently constitutional. Variability among progeny is a constantly recurrent fact; the higher the evolutionary level of the generation of progeny, the greater the variability. Consequently, aside from identical twins, we never find two puppies or two human babies exactly alike. This, it is held, gives nature a great opportunity to discover the fittest for its purposes, to favor the survival of those which are fittest, and to eliminate the unfit and the less fit. So evolution of species by natural selection and survival of the fittest is supposed to take place. Now in the case of large variations, which are referred to as mutations, some of the causes of variations, at least, are in the situation outside the organism. This is demonstrated by the fact that experiments in the field of radioactivity have produced new species among fruit flies and other lowly forms. The possibility of producing new types of humans by this means is unknown to the present writer and he does not know if it has been attempted. But it looks quite possible that mutation among higher animals, including man, may have taken place during past times We know that radioactivity is present all the time on the earth and that it is more manifest in certain places than in others. There appears to be no insuperable objection to assuming that some higher organism living in a place of heightened radioactivity was influenced genetically, with the result that a new species was the outcome. This is hypothetical, of course, but it possesses a rational foundation. It is no more conjectural than the traditional view and it is more intelligible.

During past times and among lower levels of organisms, variations and mutations were demanded or justified by environmental conditions. This signifies that the environment or some environmental conditions placed a premium on those variations and mutations

which possessed heightened survival value in that particular milieu. Nature "favored" (permitted) the survival of such forms. Environmental "demand" (pressure) for such new forms amounted to no more than that, except, of course, in the case of stimulus by radioactivity. In that sense, only, was nature seeking new forms of life, bidding for them. They could survive because of their survival value, fitness, adaptability to live in terms of conditions nature prescribed and imposed. The first men stood a better chance of surviving than did their pithecan forebears just because they had developed more resources to circumvent and make use of natural conditions. Physical nature was the total environment, practically, to which they had to adapt themselves. So this natural environment, chiefly, eliminated or perpetuated them. For this reason a new and advantageous organic form for that physical environment had a chance to be discovered by the environment and to be favored (passively) for selection and survival.

Whether or not there will be future evolution of man revolves about the part environment plays in selection and survival. The crucial consideration is that "civilized" man today is surrounded by another environment than were beginning men and that the more we become urbanized and mechanized the more this is true Culture, social environment, has largely thrust physical environment aside and constitutes the chief set of external conditions to which present men adjust themselves. Man's survival value now is rated in terms of socio-cultural conditions and standards of valuation instead of physical. During pre-cultural days nature might place a premium on physical size, strength, speed, endurance, so that the organisms best constituted in those respects were selected by nature to survive, were the fittest. But under urban and machine environmental conditions the possession of super height, super weight, super speed or other super physical attribute may not be an advantage, but sometimes even be a disadvantage. Our socio-cultural environment is not demanding mutations in those directions. We are producing mechanical devices which possess super qualities to a degree that no natural mutation could begin to compete with. Telescopes, microscopes, trains, autos, airplanes, diggers, pumps, cranes, looms, telephones, radios, loudspeakers, each in its way can outdo many fold anything that any new mutation in a human organism could possibly accomplish. In this sense, the environment today is not demanding, pressing for, placing a premium on the appearance of new, "improved" human mutants. Such mutations would have no or little survival value and consequently, if the new being did survive or were allowed to survive, he or it would possess little if any superior competitive advantages It might even occur that because of his super height or weight or farsightedness or micro-vision he could only qualify as a "freak" and travel about with sideshows to be exhibited at conventionally small admission fees Which, of course, means that if a marked mutant were born we would have no means of evaluating the departure from the normal, would not know it if it appeared, would not know what to do with it, would not "recognize" it as having any important significance. It would not be outstanding in our kind of socio-cultural environment until it had been cultured for many years. It might well get lost in the shuffle and perish.

Perhaps the only human mutation which might prove valuable would be one of brain. Whether humanity "needs" better brains is a disputable matter. Evidently better brains or better trained brains would be a distinct advantage to some people we know. But brain capacity is a matter of relativity in that it

varies by successive and innumerable gradations from the sheerest idiot to the most gifted thinker and inventor. We might agree that we need more geniuses and fewer idiots, if we did not stop to inquire what is meant by "need" and "for what" the need exists. What we would have to discuss is whether on the average we humans need more brains If we took the average of all extant mental capacities, it would be the average (mean) capacity of all gradations of capacity from idiot to genius. The average capacity might be raised by either of two means: increasing the number (proportion) of geniuses or decreasing the (number) proportion of idiots. We do not at all know how to accomplish the former and only slightly how to secure the latter result. Left to spontaneous mutations, either consequence may ensue. If a transcendent genius by nature were born, he might never be touched (stimulated) by our educational process and might disappear unknown. Unless we could discover him at birth and raise and nurture him as a genius (something we are scarcely prepared to do), he would be likely to remain as one of the estimated fifteen undeveloped and unknown native geniuses among every sixteen that are born.

Were we to develop all our potential geniuses into operational geniuses and also develop all other grades of "normal" brains up to their maximum capacity instead of to the eighth grade level as at present, the resulting increased productivity which would be manifest all through society would be so startling that we would cease to speculate on our need for better brains

HISTORY OF THE MEASUREMENT OF HEAT

II. THE CONSERVATION OF ENERGY

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THE development of quantitative thermal science may be thought of as comprising three broad stages: the first was the measurement, three hundred and fifty years ago, of heat levels or intensities through *thermometry;* this was followed about seventy-five years later by the determination of relative heat capacities or quantities through *calorimetry.* The third step was the correlation of the sciences of heat and mechanics which led a hundred years ago to *thermodynamics*

It is the aim of science to bring all phenomena, including heat, into one unified and self-consistent system. Attempts to correlate heat with mass had been signal failures; but there was another linkage which had been more or less apparent since prehistoric days. Primitive men who struck a fire through friction were aware of the fact that kindling temperatures can be produced by motion. Conversely, the experiments of Philo and Hero had shown that motion can result from differences in temperature. It was the *quantitative* form of expression given to these two simple *qualitative* observations which initiated the third period in the science of heat and led to the law of the conservation of energy.

Conservation theorems are perhaps as old as science itself. *Nihil ex nihilo* has been accepted as more or less self-evident ever since the Ionian philosophers began their search for the underlying unity and permanence in this world of apparent multiplicity and ceaseless change. In Peripatetic science there was an understanding that the visible processes of generation and corruption were but conversions in form of a basic *prima materia.* In the atomic school of Leucippus, Democritus, and the Epicureans, the indestructibility of matter had been axiomatic. All changes were but the confluence and separation of primeval atoms The eternity of motion as well as matter was implied by the teaching of the ancient atomists and by the medieval concept of inertia; but it was first given explicit expression in modern times by Descartes. In 1644 he held that the universe was a plenum to the matter of which God had in the beginning imparted a given totality of vortical movement. This motion endured eternally, because of the contiguity of the particles of matter throughout all space, and remained quantitatively invariant.

The philosophical principles of the conservation of mass and motion were paralleled by similar laws based upon mathematical and experimental physics. The law of the lever is a simple illustration of the mechanical rule that what is gained in power is lost in distance. That is, it represents an adumbration of the compensation idea or the law of the conservation of work. This general principle is implied also in the postulate of the impossibility of perpetual motion from which Stevin in 1586 deduced his principles of hydrostatics, the law of the inclined plane, and the idea of statical moment. Galileo saw the same principle in operation in the fact that a pendulum bob was found never to rise above the height from which it had fallen. Torricelli and Huygens stated more generally that the common center of gravity of a

system of bodies cannot of itself rise above the height from which it fell. From the observations of these men the concept of work and the law of the conservation of mechanical energy in an isolated system gradually were crystallized out during the sevententh century.

For almost a century following the death of Descartes there raged between the Cartesians and Leibnizians a controversy arising from an apparent inconsistency between the philosophical doctrine of the conservation of motion and the mathematical definition of work. The term motion at that time was understood to mean the product of mass and velocity, or what now is called momentum. On examining the matter closely, Huygens concluded that Descartes had been wrong. From the concept of work it followed that in certain cases of elastic impact the sum of the momenta after impact was definitely not equal to that beforehand. Had Huygens in these cases subtracted rather than added the momenta, he would have found that the principle of Descartes was indeed justified if corrected to state that the total momentum *in any given direction* is the same after impact (elastic or inelastic) as before. This law of the conservation of directed momentum or of mechanical effect is, in fact, essentially equivalent to Newton's third law of motion. Although Huygens overlooked the possible correction of Descartes' law, he discovered about 1669 the striking fact that if one multiplies each mass by the *square* of the velocity, rather than by the first power, then in all cases of perfectly elastic impact the sum of these products remains the same after impact as it was before. This focussed attention upon a new entity—the product of mass and the square of velocity, or what Leibniz called *vis viva*. This is essentially what is now known, in the form $\frac{1}{2}mv^2$, as kinetic energy.

Meanwhile it had been recognized that mv or momentum was equivalent to the product of force and time, whereas $[\frac{1}{2}]mv^2$ or *vis viva* was equivalent to the product of force and distance. Cartesians maintained that the efficacy of a force was measured by the time through which it acted; Leibnizians insisted that the efficacy was a function of the distance. Two hundred years ago this famous controversy came to an end when D'Alembert in 1743 showed that the dispute was merely one of terminology. The efficacy can be measured in terms of the product of force by either time or distance, the difference lying only in the units chosen. Mechanical energy, whether measured as momentum or as kinetic energy, is always conserved under perfectly elastic impact, as the so-called principle of D'Alembert indicates.

But what of inelastic impact? Leibniz about 1686 had sought to generalize Huygens' result for this case also and to establish it as a cosmological doctrine. He saw that *vis viva* was essentially equivalent to work, and that possibly it existed also in other forms as a sort of potentiality. The terms kinetic energy, work, and potential energy now have precise and distinctive meanings, but Leibniz referred rather loosely to all three when he spoke of the great universal law of the conservation of force or *vis viva*. This law he regarded as justified by a general equality principle, *Causa aequat effectum,* which is somewhat equivalent to Newton's law of action and reaction, published in 1687.

For almost half a century the law of Leibniz went more or less unnoticed, possibly because Newton cast doubt on its validity. Nevertheless, in 1731 Christian Wolff asserted again that *vis viva* remains constant in *all* cases of impact. In 1735 Jean Bernoulli discussed the nature of force and concluded that it was something real and substantial, and hence must be invariable in quantity. In cases of inelastic impact he believed that any apparent loss of *vis*

viva corresponds, because of the equality of cause and effect, to some form of potential energy, such as a force of compression of the bodies. The idea of potential energy had been adumbrated by Gassendi and Borelli, and had been expressed somewhat more definitely by Leibniz. Daniel Bernoulli, son of Jean, in 1738 gave a clear distinction between actual and potential motion—or between kinetic and potential energy—in the principle which bears his name. This principle, like that of D'Alembert, is equivalent to the conservation of mechanical energy for perfect machines; but Daniel Bernoulli held that the law of the conservation of *vis viva* was valid for all situations, terrestrial and celestial. It is indeed surprising that he did not anticipate the general conservation of energy more definitely. He adopted the idea of internal energy and the kinetic theory both of gases and of heat. Nevertheless, although he expressed the belief that a cubic foot of coal contained the work-equivalent of 8 to 10 men for one day, he did not calculate a definite mechanical equivalent of heat.

In 1742 Voltaire's mistress, the Marquise de Châtelet, likewise expressed the compensation idea. She admitted that in cases of inelastic impact it is difficult to follow the course of the *vis viva,* and that some appears to be lost. Nevertheless, she was quite certain that the force had not in reality perished. Such confidence, however, failed to convince others, and the law was largely forgotten until precisely a century later when Mayer showed clearly that it was justified. Any apparent loss is the result of a conversion of *vis viva* into some latent form which, as Daniel Bernoulli had suspected, in many cases is nothing but heat.

The one-hundred-year delay in the establishment of the law of the conservation of energy is striking. The difficulty with all the enunciations of the law put forth between 1686 and 1742 was that they were at best bold extrapolations beyond experimental evidence which were justified by faith in the unity of nature. Only in cases of perfectly elastic impact had Huygens shown that *vis viva* remains constant D'Alembert in 1743 warned against the metaphysical point of view which would make a primitive universal law of nature out of something holding only in certain definite cases. His warning was observed for almost a century. Then Mayer in 1842 boldly repeated *Causa aequat effectum.* In 1843 Joule similarly asserted that "the grand agents of nature are by the Creator's fiat, indestructible"; and Colding in this same year maintained that "force is a thing, imperishable and immortal." In such metaphysical terms did these men re-enunciate the law of the conservation of energy. However, D'Alembert himself would have excused them, for their pronouncements were accompanied by what had heretofore been lacking—precise quantitative experimental evidence. But to understand their work it will be necessary to return to the question of the nature of heat.

On numerous occasions, particularly during the seventeenth and eighteenth centuries, it had been suggested that heat was the result of a rapid motion of the parts of the matter affected. Until 1798, however, no one had been able to show that heat was indeed measurable in terms of momentum or kinetic energy. In that year Count Rumford reported on his spectacular and classic experiments at the Munich arsenal on the heat generated during the boring of cannon. That very high temperatures could be obtained through friction was a commonplace known even to neolithic man. This phenomena was readily explained by theoretical science as due either to the liberation of caloric from the abraded materials (or perhaps from the surrounding atmosphere) or else to the generation of vibrations among the particles of the substances. That is, the

materialistic theory found the source of heat *within* the substances and looked upon the frictional motion as simply the agent which converted this internal latent heat to sensible heat; the dynamic theory, on the other hand, interpreted the change in temperature as the conversion of *external* mechanical energy to an increased internal energy of vibratory motion. Either explanation was *qualitatively* satisfactory. Rumford, however, noted a strong *quantitative* argument against the caloric theory. The source of the heat generated by friction in these experiments appeared evidently to be inexhaustible! The equivalent of 26.58 pounds of ice-cold water had been made to boil in 2½ hours by the friction produced by machinery which could easily be powered by one horse. Given sufficient time, an indefinitely large amount of heat could be engendered. Moreover, calorimetric tests showed that there had been no perceptible loss of heat capacity on the part of the metal from which the heat came. "It is hardly necessary to add," said Count Rumford, "that anything which any insulated body, or system of bodies, can continue to furnish without limitation, can not possibly be a material substance." Rumford suggested that heat was rather a condition of bodies—a mode of motion.

Rumford's apparatus was not in reality completely insulated, for it remained in contact with the air. Moreover, the constancy of the heat *capacity* of the metal chips did not prove that a constant *quantity* of heat was retained. Hence his work was not thoroughly convincing. The following year Davy gave further evidence that heat is not matter. He showed in 1799 that two pieces of ice might be melted simply by rubbing them together vigorously. In this case also, however, it could be argued that the heat necessary to melt the ice somehow had come, not from the frictional motion, but from the air. Davy therefore performed a second experiment in which two pieces of metal in contact with wax were mounted on ice and rubbed together by clockwork in a receiver which had been exhausted by an air pump. In spite of the effort to remove every possible source of heat, the friction here produced a rise in temperature sufficient to melt the wax. Davy concluded from this that friction does not diminish the capacity of bodies for heat; but that heat may be defined as "a peculiar motion, probably a vibration, of the corpuscles of bodies, tending to separate them."

The experiments of the young and inexperienced Davy did not carry conviction. Although the vibration theory in 1807 was accepted by Young (who first substituted the word energy for *vis visa*) and somewhat later by Ampère, the caloric doctrine continued to predominate for another half century. One reason for the delay in the acceptance of the kinetic theory of heat may be found in the fact that before 1842 no precise and explicit conversion figure was given for thermal and mechanical energies. From Rumford's data one can indeed calculate, on the basis of Watt's estimate of one horsepower as equivalent to 33,000 foot-pounds per minute, a mechanical equivalent of heat of 1034 foot-pounds per British thermal unit. However, the idea of a constant proportionality factor in the conversion of work into heat is more implied than expressed in his account. Rumford did not pursue the theoretical implications of his experiments and left unanswered the knotty inverse question of the quantitative convertibility of heat into mechanical effect.

The problem of converting heat into work had up to this time remained largely in a qualitative stage. The contrivances of Philo and Hero were primitive means of achieving such a conversion, but no attempt was made to measure the heat expended or the work done. The improvement of these devices by Porta, de Caus, Branca, the Marquis of Worcester, Savery, Papin, and New-

comen resulted in more practical heat engines; but Watt saw that they were still exceedingly wasteful of fuel. Watt's mechanical ingenuity enabled him in 1769 to patent a machine with a separate condenser which was so great an improvement over earlier forms that often he is regarded as the effective inventor of the steam engine. Moreover, he was unusually sensitive to the need for precise measurement. He gave definite numerical significance to the term horsepower; he discovered the quantitative composition of water independently of Cavendish and Lavoisier; and he was inspired by Black to make careful determinations of specific and latent heats. Nevertheless, it remained for Sadi Carnot to establish in 1824 the quantitative theory of the engine which Watt had improved.

Carnot's thought was influenced to a large extent by Fourier's mathematical analysis of thermal conduction and radiation. Fourier had remarked, as had Lambert a half century before, that differences in temperature were somewhat analogous to differences in water level in that the work which could be obtained from the system depended both on the difference in level, or potential, and on the quantity. This would seem to imply that with heat, as with water power, the quantity of the working substance is the same at the end of operations as beforehand. Carnot accepted this conclusion and in his early work looked upon heat as material Work was not the result of a conversion or loss of heat, but was due wholly to letting caloric down from a higher to a lower temperature or potential. He found, however, that the quantity of work was not directly proportional to the difference in potential. His calculations showed that motive power is given in terms of temperature by a function according to which the efficiency drops off with an increase in the temperature of the condensor or sink. This observation later became the basis for the *second* law of thermodynamics, but Carnot's early materialistic views obscured the way toward the *first* law. Carnot computed that 1.12 units (kilogram-meters) of work were furnished when 1000 units (kilocalories) of heat passed from 100° to 99° C. If one were to read into Carnot's work the ideas of entropy and the dynamic theory of heat, this estimate would give a mechanical equivalent of about 418 kilogram-meters per kilocalorie; but Carnot did not interpret his calculation as a conversion of heat into mechanical effect, for he thought of the quantity of heat as unchanged. Soon after 1824, however, Carnot seems to have become a convert to the mechanical theory of heat. In an undated manuscript of this period he said: "Motive power is in quantity invariable in nature; it is, correctly speaking, never either produced or destroyed." Moreover, this clear enunciation of the conservation of energy differed from statements of a century before in that it included the first precise value for the mechanical equivalent of heat. Carnot calculated from the specific heats of air that the creation of a unit of motive force resulted from the destruction or conversion of 2.70 units of heat. This figure is less accurate than that implied by the work of 1824, but it was based upon the modern view of heat and energy. Unfortunately, Carnot's premature death in 1832 prevented him from elaborating on the implications of this work and from publishing an account. It remained unknown until the brief manuscript note was discovered and published about a half century later. Meanwhile, there were in the decade from 1837 to 1847 no fewer than half a dozen men who, quite independently of each other, pursued the same line of thought and share in the discovery of the conservation of energy.

Speculation on the general conservation of mechanical effect, latent as well as patent, had been largely abandoned

about a century earlier. In the case of frictionless machines the idea of compensation, or the conservation of work, continued to be accepted as axiomatic in mathematical treatments of mechanics; and the Paris Académie by 1775 had decided to reject all papers on perpetual motion. Work done against friction, on the other hand, was regarded as in a sense wasted, lost, and destroyed. However, during the early nineteenth century evidence from new sources pointed to closer quantitative interrelations between natural phenomena. Galvani and Volta had shown, just before the century opened, that chemical forces were convertible into a continuous electrical current; and Nicholson and Carlisle in 1800 had indicated the converse. Then Oersted in 1819 disclosed that galvanism and magnetic forces can generate motion; and Faraday in 1831 discovered inversely that motion and magnetism can produce current electricity. In 1833 John Herschel pointed out that solar influence was indirectly the source of all motion on the earth. Such disclosures led Mohr in 1837 and Grove in 1842 to assert that motion, heat, light, chemical affinity, electricity, and magnetism are but different forms of force or energy. They are mutually dependent and when one form disappears another appears to take its place. Mohr suggested, but did not complete, a calculation of the work-equivalent of heat from the specific heats of air.

Two years later Séguin studied the steam engine in order to measure the difference between the heat which had left the boiler and that which reached the condenser. Having adopted the mechanical theory of heat from his uncle, the famous balloonist Montgolfier, he maintained that the heat lost during the expansion of steam is necessarily equivalent to the work done during this expansion. In 1839 he gave data from which the mechanical equivalent of heat can be calculated. In 1847 he made an explicit calculation and arrived at about 449 kilogram-meters; but by then he had been anticipated by Mayer, Colding, and Joule.

In 1840 Mayer journeyed to Java as surgeon on a Dutch vessel. In bleeding patients he was surprised at the bright red color of venous blood of men in the tropics. He concluded, on the basis of Lavoisier's work, that this was due to a lower metabolic rate in torrid zones which called for a smaller consumption of oxygen and resulted in less color contrast between venous and arterial blood. He came to realize more keenly the relationships between food, heat, and work. Mayer was convinced, on the basis of metaphysical principles, that heat and work are qualitatively different forms of something which is quantitatively indestructible. He was aware that such a general principle would have to be supported by very definite empirical evidence before it could meet with the approval of critical scientists. Mayer was lacking in mathematical and experimental technique, but he adopted the method which Mohr earlier had suggested for calculating, from calorimetric data well known to the world of science, the mechanical equivalent of heat.

Mayer maintained that the heat evolved when air is compressed is the dynamical equivalent of the work employed in compressing it. On this basis he made the assumption, later fully justified by the experiments of Joule, that the specific heat of a gas at constant volume exceeds the specific heat at constant pressure by a quantity of heat equivalent to the work which the gas in the former case will do if allowed to expand to its original pressure. On carrying out the necessary calculations, Mayer concluded that 1 unit (calorie) of heat will raise 1 gram about 367 meters.

Mayer was not first in enunciating a general principle of the conservation of energy, nor was he first in calculating the mechanical equivalent of heat. He

is, however, entitled to priority as the first person to *publish* a clear, explicit *statement of the principle* together with a precise and reasonably accurate *value of the mechanical equivalent* derived from experimental data. Nevertheless, there were others who must be recognized as independent co-discoverers. Colding, for one, was led to similar ideas at roughly the same time About 1839 he was puzzled by a study of D'Alembert's principle of active and lost forces. He concluded that, inasmuch as the forces of nature are akin to the intellect in being something spiritual and immaterial, they ought to be regarded as absolutely imperishable. Therefore, "when and wherever force seems to vanish in performing certain mechanical, chemical, or other work, the force then merely undergoes a transformation and reappears in a new form, but of the original amount." Whereas Mayer had recourse to the scientific data at hand in calculating the mechanical equivalent of heat, Colding collected new data from a variety of experiments on the heat of friction. From some two hundred measurements he arrived at a figure of about 350 kilogram-meters; but he was encouraged by Oersted not to put his idea before the Royal Society of Science at Copenhagen until he could give an experimental demonstration of it. Hence, his "introductory" presentation was delayed until 1843, at which time similar conclusions of Joule, based upon more complete and accurate experimental data, obscured Colding's achievement. However, Joule's work likewise had been delayed by his observance of Herschel's advice that "hasty generalization is the bane of science."

While Colding was pondering over the principle of D'Alembert, and Mayer was on his way to Java, Joule presented his first papers on the relations between chemical, electrical, and thermal energy. Faraday's laws of electrolysis had shown that chemical affinity and electromotive force are quantitatively related. Joule extended this to show that *chemical and electrical energy are quantitatively equivalent to the heat produced* in the electrical circuit, both in conductors and in voltaic and electrolytic cells. But Faraday in 1831 had shown that electrical currents could be produced mechanically as well as chemically. Joule saw that the heat produced by a current from a dynamo should be the same as the heat of friction which would have been generated directly by the force operating the dynamo if it had not first been converted into an electric current. Joule therefore measured the work done in producing a current through electromagnetic induction and calculated the *mechanical equivalent of electrical energy*. Then through his previous work on the *electrical* equivalent of heat he deduced as the *mechanical* equivalent of heat the value 838 foot-pounds per British thermal unit.

The work of Joule stands in sharp contrast to that of Mayer. For Mayer the conservation law had been in the nature of a sudden intuition, or at best a philosophical discovery supported by a somewhat slender bit of calculation; for Joule it represented an inductive inference justified by a wealth of accurate data derived from a variety of experiments skilfully devised and patiently executed. Joule was not satisfied to determine the mechanical equivalent of heat from one experiment or even from a single series of experiments. As a postscript to his paper of 1843 he supplemented his mechanical-electrical-thermal calculations by a method eliminating the electrical step. By forcing water through fine tubes—Carnot had suggested this method in his unpublished manuscript—Joule found directly an equivalent of about 770 foot-pounds. Two years later he deduced the value 798 through the heat disengaged and the work done on compressing air. From 1845 to 1847 he carried out his favorite method on the fric-

tion of liquids produced by paddles and falling weights, obtaining about 782. His final estimate of the mechanical equivalent derived from all of his work was 772 foot-pounds.

Before 1847 the law of the conservation of energy had been independently adumbrated in forms of varying degrees of accuracy and generality by Rumford, Carnot, Mohr, Séguin, Colding, Mayer, and Joule. Yet the principle of conservation neither carried conviction nor was widely known The task of making it scientifically acceptable was reserved for still another discoverer, von Helmholtz. He was a physiologist who, like Galvani and Volta, worked on the muscles and nerves of frogs' legs Helmholtz wished to banish from biology the concept of vital force and so sought to measure the heat produced in muscles during chemical changes. From such studies he was first led to the conservation of energy. However, the many-sided Helmholtz was also a physicist and mathematician, and so he sought to establish the law upon a sound postulational basis similar to Lagrange's treatment of mechanics. He found the necessary first principles in the work of Stevin and Newton—in the impossibility of a perpetual motion and in Newton's third law. Through an elaborate mathematical discussion he showed that all the known cases of the transformation of energy could be traced back to these principles, and from them Helmholtz deduced the law which he called *The Conservation of Force.*

The law of the conservation of energy states that in any inter-transformation of heat and molar motion (or of any two types of energy), the amount of that form of energy which disappears is exactly equivalent to the amount of the other form which is created. In this respect the two forms are on the same basis. However, Carnot had found that motion and heat are not mutually and completely interchangeable. Given a quantity of mechanical energy, it is indeed possible to convert this fully and completely into heat. However, the converse can never be true, and it is this fact which at first prevented Kelvin and others from accepting the full significance of Joule's work. At best only a fractional part of a given preassigned quantity of heat energy can be converted directly or indirectly into work. At worst none may be so converted, as when the temperature of a free bar, the ends of which are unequally heated, is allowed to become uniform This had been pointed out by Carnot in his classic work of 1824. Carnot based his reasoning on the idea of heat as an indestructible fluid, but his arguments and conclusions hold also, *mutatis mutandis,* for the dynamic theory of heat. Carnot saw that if the working substance can be brought back to its initial state, one will be in a position to tell precisely how much heat and work have been involved. This led him to the study of the so-called Carnot cycle. On the basis of this cycle and the impossibility of perpetual motion, he realized that no heat engine can be more efficient than one which is reversible. In all other cases, although there is no loss of energy, only a portion of the heat is convertible into work. Carnot thus recognized essentially the operation of the second law of thermodynamics, and the expression $(T_2 - T_1)/T_2$, which determines the convertible fraction, is now appropriately known as "Carnot's function"; but at the time the implications of his work were overlooked.

During the early years of the second half of the nineteenth century it was recognized by Clausius and Kelvin that the Carnot efficiency function has far-reaching implications. No known process in nature is exactly reversible and hence during *every* transformation of heat into work some heat energy, while not destroyed, is nevertheless rendered unavailable. Temperatures tend to be equalized, and work can be obtained from

heat only when there exists a difference in potential or temperature. Although the total *energy content* of the universe remains the same, yet the amount which is *available* tends constantly to diminish. This recognition led to the pronouncement by Kelvin and Clausius that unless some other force intervenes, the universe is approaching a "heat death" in which there will be no differences in temperature, and hence no energy available for work, activity, and life.

The law of the conservation of energy probably did more than anything else to establish the dynamic theory of heat. Yet as Mach showed, the laws of thermodynamics are not necessarily inconsistent with other views of the nature of heat. Carnot, in fact, had practically anticipated the first two laws on the basis of a material theory. Such doubts as remained with respect to the mechanical view of heat disappeared about the middle of the last century. One reason for this was that atomic and molecular theory was then firmly established in chemistry. Moreover, successful physical studies of the internal forces which constitute heat already had been made—at least for the less complicated case of the gaseous state of aggregation. Daniel Bernoulli had advanced the kinetic theory of gases from a quantitative point of view, but his work of 1738 was largely neglected until revived and extended by Le Sage and Prévost (1818), Herapath (1847), and Joule (1848) to include the calculation of the velocities of the molecules for various temperatures and the determination that the heat capacity of a gas is given directly by its *vis viva.* In the next few years Rankin, Clausius, and Kelvin showed that intramolecular forces also must be considered a part of the phenomena of heat; and Clausius (1859) and Maxwell (1860) extended Joule's calculations to include the mean free path, the distance between centers at collision, and the number of molecules per unit volume. Such *quantitative* expression constituted confirmation of the kinetic view which was more convincing even than the striking *qualitative* evidence presented in 1827 by the Brownian movement. After this work chemists accepted atoms and molecules as real and substantial; and physicists by that time were thoroughly convinced that it is the motion of these particles which produces the sensation known as heat.

* * * * *

Twenty-five hundred years ago Pythagoras uttered the dictum, "All is number." This was reaffirmed by Plato in the words, echoed in our day by Whitehead, "God is a geometer." Science has come to reject the Pythagorean-Platonic teleological form of such a view; but it has found ever greater confirmation of the corollary that "to measure is to know." In this respect the science of heat has been far from exceptional. A brief review of such quantitative aspects as thermometry, calorimetry, and thermodynamics does not indeed exhaust the subject of the theory of heat; but further investigation into these and other branches will amply confirm the impression which such an elementary review has afforded. Here, as in other fields of science, it was an insistence upon quantitative methods which made possible the development in theory. Qualitative notions on the nature and properties of heat began to take on significance only when, three hundred and fifty years ago, a crude instrument was devised to give them quantitative form. Two and a half centuries later thermometry gave rise to what was at the time the greatest unifying principle of all science. There was in this dynamic changing universe one entity which remained eternally the same—the quantity of energy. As science goes on in the search for still greater unity, let it be remembered that the way is paved, not with unmeasured speculation, but with the objective data of patient quantitative research.

WATER—THE UNIVERSAL ADULTERANT

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Water is a vital necessity in our social life, and for our physiological processes. We can abstain from food for a much longer time than from water and still live to tell the tale. Without sufficient water our crops would fail, our animals used for food would die, and the human animal would perish from hunger and thirst. Wars have been waged over water holes. Cities, states, and nations have spent, and will continue to spend, vast sums in order to deliver to their citizens an abundant supply of pure, fresh water.

Water has many commercial usages. It is used for the production of power; it is extensively used as a cleaning agent. It is used as a solvent in the household, as well as in the arts. Its application as an adulterant of many articles of merchandise depends largely upon its unique solvent properties. In fact, water, in addition to being the universal solvent, may well be considered as almost the universal adulterant, and its use as an adulterant is responsible for the term "watered stocks." The detection of added water is often difficult because of variance in the natural moisture content of the substances which are thus adulterated.

Foods

Milk. The watering of milk is historic, prehistoric, and no doubt will continue as long as the human race uses milk and desires an excess profit.

The watering of milk in Massachusetts was formerly more prevalent than at present. Its reduction has been brought about by the discovery of methods for the detection of this form of adulteration, and by the imposition of substantial fines. The practice, now so frequently used, of buying milk by "weight and test" is also responsible for this reduction. It is not profitable to water milk when it is sold on a 3 7 per cent fat basis.

Average market milk is 87.4 per cent water, but natural milk will vary between 83 and 90 per cent water The addition of 15 per cent of water to average market milk will increase the water content to 89 2 per cent which is less than the water content of certain natural milk.

A small amount of added water may be detected by the freezing point of milk, or by the determination of the refractive index and ash of the milk serum. A larger quantity may be detected by the specific gravity and sometimes by the taste of the milk. A much larger quantity may be detected visually. The quantity of watered milk sold is extremely small relative to the total milk supply.

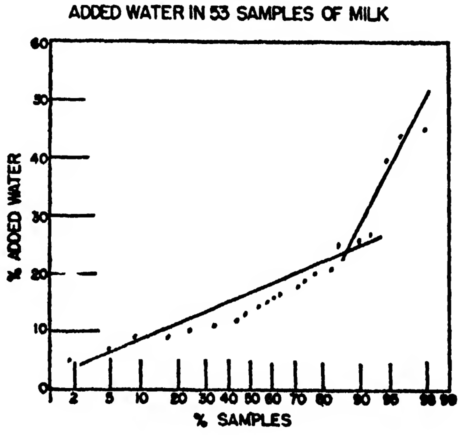


FIG. 1.

In order to show the variation of added water in adulterated milk, the records of the year 1925 were selected.

During that period 6,813 samples were collected and 150 samples of watered milk were obtained from fifty-three persons, from one to eight samples being taken simultaneously from each person. The median analysis of the samples taken from each person represents the fifty-three analyses reported upon Figure 1 with arithmetic probability scales. These figures plot as two probability series. One series represents ninety per cent of the samples which were obtained from those who desired to play a more or less reasonably safe game, and the other ten per cent was obtained from those who watered the product they were selling without regard to the possibility of detection and subsequent litigation.

During 1942, 5,649 samples of milk were collected, of which fifty-one contained added water. Eight of the nine persons responsible were prosecuted and convicted. The ninth person was out of our jurisdiction, the milk having been shipped into Massachusetts from another state.

Butter. Butter is a mixture of milk fat, water, casein, salt, lactic acid, and color. Of these substances, fat is the most expensive and water the cheapest. After the passage of the United States Food and Drug Law of 1906, the Secretary of Agriculture, under the provisions of the Act, adopted a minimum standard of 82.5 per cent butter fat Unfortunately, the United States Law of 1906 provided no penalty for non-compliance with the standards[1] Most of the states adopted this United States standard, the state laws providing penalties for violations. Non-compliance with the standard began to be the rule, and appeals to the United States Department of Agriculture for action in interstate shipments of low standard butter were often ignored. Massachusetts was informed that no action would be taken under the United States law unless fat was less than eighty per cent *and* water above sixteen per cent. The following is quoted from the 1921 report of R. O. Baird, Chief Deputy Food Commissioner of North Dakota:

> The standard for butter which is used as a guide by the federal and most of the state and city food officials requires that butter shall contain not less than 82 5 per cent milk fat. This leaves 17.5 per cent for salt, curd, coloring matter, and moisture. On the average something less than 16 per cent will represent moisture.
>
> The federal officials do not recommend seizure when the butter contains as much as 80 per cent milk fat and is otherwise in accordance with the law.
>
> The sale of water and salt at the price of butter is not only a fraud upon the consumer and an unnecessary burden upon the public, but is also demoralizing to the butter industry.
>
> The man who puts excess water in his butter can cut the price sufficiently to get the business and still make more than a fair profit. The cut price, however, seldom reaches the consumer, since the additional water is not apparent and the butter usually is sold at regular market prices. As a rule, the manufacturer and the dealer thus divide between them the profit on water sold as butter.

The literature shows that the moisture content of butter is quite variable. Konig reports 317 analyses made between 1864 and 1895, showing moisture variation from 4.15 per cent to 35.12 per cent and averaging 13.45 per cent. The United States Bureau of Animal Industry published, in 1912, 692 analyses of butter with moisture varying from ten per cent to eighteen per cent, with a median of fifteen per cent. The Massachusetts Department of Public Health in 1923 and 1924 examined 502 samples of butter, some of which had been in storage for nearly a year, the moisture of which varied from 8 per cent to 18.5 per cent, averaging 14.7 per cent. A report on New Zealand export butter gives 828 analyses above 16 per cent moisture, averaging 16.38 per cent, and 144,952 analyses below 16 per cent moisture, averaging 15.04 per cent. moisture.

[1] The new Food, Drug, and Cosmetic Law provides a penalty for violating the standards and regulations of the U. S. Food Administration.

In 1940, C. S. Ladd, then North Dakota Food Commissioner and State Chemist, published the results of the analyses of 513 samples of butter to be sold under the 80 per cent fat standard enacted by Congress in 1924. The following table gives a summary of the results:

ANALYSES OF NORTH DAKOTA BUTTER IN 1921 AND 1940

	Moisture		*Fat*	
	1921	*1940*	*1921*	*1940*
	%	%	%	%
Lowest	12.3	12.7	67.7	76.9
Lower quartile	14.0	15.5	78.9	80.3
Median	15.0	15.9	80.3	80.8
Average	15.3	16.0	80.1	80.9
Upper quartile	16.2	16.4	82.0	81.2
Highest	29.5	19.7	85.0	85.3

It is evident that a reduction in the standard did not cause any reduction but rather an improvement in quality, although it resulted in a reduction in law violation.

The art of manufacturing butter has progressed towards the elimination of excess moisture as well as low moisture; and it is progressing towards the production of butter less variable but relatively higher in moisture.

It should not be assumed that the federal authorities are lax in the enforcement of the fat standard for butter. The notices of judgment of the United States Food Administration frequently report prosecutions as well as seizures for selling butter containing less than eighty per cent fat.

Condensed Milk. Forty years ago condensed milk was more condensed and consequently contained less water. Standard brands contained from nine to twelve per cent fat and twenty-eight to thirty-seven per cent milk solids. Condensed milk now upon the market very closely approximates the standards of not less than 25.5 per cent solids, 7.8 per cent fat for the unsweetened variety; and 28.8 per cent milk solids, 8 per cent fat for the sweetened variety. The high concentration of the milk formerly on the market caused a crystallization of some of the milk sugar, which many purchasers insisted was sand. The lower concentration prevented this crystallization, and purchasers are now satisfied with the product. This reduction in concentration can hardly be considered as adulteration

Cheese. The moisture content of food can be somewhat increased by adding a substance capable of absorbing many times its weight of water. A few years ago the water content of cream cheese was increased by this means. Some manufacturers added certain vegetable gums and sold the diluted product in competition with other manufacturers not using these gums. At the instigation of the manufacturers a change was made in the Massachusetts law permitting the practice of adding gums to cream cheese, and specifying a maximum moisture content of fifty-six per cent and a minimum fat content of seventy per cent on the moisture-free basis. Even now some manufacturers violate this standard which was made according to their own specifications. The Federal Food Administration by regulation now permits the addition of gums to cream cheese, and has prescribed moisture and fat standards for that article. The reason given by the trade for the addition of gum to cream cheese was to "prevent leaking."

Sausage. Another article of food containing more or less added moisture is the sausage. It seems that water is a necessary ingredient in its manufacture. The Supreme Court of Michigan, after considering extensive evidence, rendered a lengthy decision stating in part, "(a) Water is an essential ingredient in the manufacture of sausage, whether made with or without cereal." The Court also

stated, "It is conceded that the use of cereal requires more water than does sausage made from meat alone. Anyone of intelligence would, upon reflection, know this to be a fact." The addition of large quantities of water, however, is prevented by placing a limit (two per cent in Massachusetts) upon the content of "cereal or vegetable flour or any product thereof." Starch will absorb four times its weight of the water in which it is cooked. Starch is sometimes added to pork sausages and since these articles are not cooked prior to sale, the starch will not carry excess water. In this instance, the starch is added for the purpose of absorbing the excess fat during the cooking process, and the consumer eats a higher fat, lower protein, pork sausage than if he purchased a somewhat more expensive sausage containing less fat, more protein, and no starch.

Vukenack and Sendtner, interested in the use of color as a means of increasing the fat and reducing the proteins, report forty-nine analyses of sausages averaging as follows:

ANALYSIS OF SAUSAGES

No. of samples	*Character*	*Water*	*Fat*	*Protein*
		%	%	%
8	Uncolored mettwürste	35.4	40.8	19 0
8	Colored mettwürste	33.6	48.3	14 4
9	Uncolored cervelatwürste	24.2	45.9	23.9
6	Colored cervelatwürste	22.8	51.8	19.3
5	Uncolored salamiwürste	17.0	48.4	27.8
6	Colored salamiwürste	16.2	54.1	23.3
4	Uncolored rindfleischwürste[3]	48.0	27.0	20.3
3	Colored rindfleischwürste	50.6	26.0	19.6

The German sausage of 1899 was fairly dry. The A.O.A.C. formula for added water gives negative values in each instance from the above figures. M. Kreis reports the analyses of twenty-one Swiss sausages in 1907 as follows: Water forty-six to forty-nine per cent; fat twelve to twenty-five per cent; fat-free flesh eighteen to thirty per cent. John P. Street reports the moisture content of fifty-one samples of pork sausage examined in 1909 as follows:

MOISTURE CONTENT OF PORK SAUSAGES

Samples	*Moisture %*
18	32 to 39
26	40 to 47
3	48 to 55
4	56 to 58

Analyses of frankfort and bologna sausage made by this Department in 1943 showed moisture variation from 49 to 61 per cent, averaging 54.9, and protein from 12 3 to 14 8 per cent, averaging 13 7. Forty per cent of these samples, some of which contained soy bean meal, showed added water by the A.O.A.C. method.

Kichton reports some interesting experiments where the same meat mixture was mixed with varying amounts of water with and without the addition of starch. After cooking for fifteen minutes, sausage with no added water contained 51.5 per cent moisture; with 10 per cent added water it contained 53.7 per cent moisture; with 10 per cent added water and 2 per cent starch it contained 56.7 per cent moisture. Another series shows with no added water, 44.1 per cent moisture; with 30 per cent added water, 52.5 per cent moisture; with 30 per cent added water and 3 per cent starch, 59 per cent moisture. The figures from both these series are shown in Figure 2 on arithmetic logarithmic scales. The lines representing the material containing starch are not parallel, that relating to the 3 per cent starch

[3] Beef sausage.

mixture showing a more rapid increase in moisture as the added water is increased than does that relating to the 2 per cent starch mixture.

TOTAL WATER & ADDED WATER IN SAUSAGES

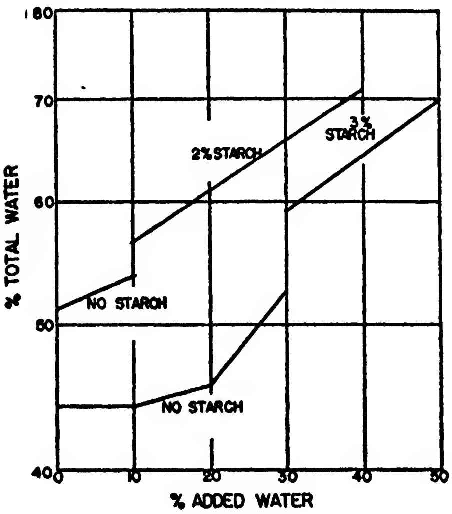


FIG. 2.

The following statement from a recent patent may be of interest. "There is introduced into the filler of a sausage casing a minor proportion of an edible water-absorbent vegetable gum such as agar-agar or gum arabic sufficient substantially to obstruct egress of moisture from the casing during hot processing and to jell the free moisture residual in the casing when the sausage is cooled so as to avoid wrinkling."

Hamburg Steak. Hamburg steak should preferably be ground by the consumer in his own home for, in this way he avoids the possibility of hamburg from more or less decomposed meat or hamburg forced through a dirty grinder. He avoids the addition of pork and thus is not likely to acquire trichinosis if he prefers his hamburg rare; and he also avoids the sulfited variety which is likely to carry from five to ten per cent water Sodium sulfite is too slightly antiseptic to be of any practical value, but it possesses substantial deodorizing properties.

BEVERAGES

Soft Drinks. Carbonated non-alcoholic beverages are mixtures of carbonated water, sugar, vegetable acids, color and flavor. Color and flavor constitute but a fraction of a per cent of the total material. Sugar is quantitatively the most costly of the ingredients. Since there are no standards for the sugar content of soft drinks, the variation is considerable in materials of similar character put out by different manufacturers. There is also a variance in the sugar content of soft drinks of different flavors. Ginger ale, sold under the paradoxical term "dry" ginger ale, for example, has a lower sugar content than other ginger ales and is consequently wetter and often better.

The Massachusetts Department of Public Health, several years ago, examined several hundred samples of soft drinks. Excluding the samples found to contain saccharine, the variance in sugar was from seven to seventeen per cent, the average being 11 per cent. During 1942, the sugar content of one hundred twenty-six samples of carbonated beverages varied from 11.3 per cent to 12.7 per cent averaging 11.9 per cent. Notwithstanding the recent sugar shortage, there was no cheapening of these products.

It was found that the sugar content of eighty-seven samples of ginger ale varied between seven and thirteen per cent, with one-half the samples between eight and ten per cent. The sugar content of one hundred seventy samples of sarsaparilla, birch beer, and root beer varied between seven and fifteen per cent, with one-half the samples between nine and eleven per cent, somewhat higher than that of the ginger ale. This excess water in ginger ale can not be regarded legally as adulteration.

Excess water, however, can be used solely for adulterating purpose if an artificial sweetener, such as saccharine,

is used to offset the reduction of sweetness by dilution. Saccharine is an organic chemical of no food value. One pound of saccharine costs $1.50, or about $1 33 per pound more than sugar. The sweetening power of a pound is equivalent, however, to $27.50 worth of sugar. A solution of one part of saccharine in 550 parts of water can be substituted for equal weights of sugar. The sugar content of twenty-four samples of soft drinks containing saccharine was found to vary between four and nine per cent. Taking the average of these figures and comparing it with the average of the 617 samples found to be free from saccharine, the average adulteration by the addition of water was forty-three per cent. The samples collected during the past three years have been free from saccharine

Scallops, Oysters, and Clams. Scallops are muscles which open and shut the shells of the bivalve so called. The balance of the animal is discarded. This form of shellfish does not require the washing so necessary with other shellfish, and consequently can be sold without the addition of water. Many years ago, scallop dealers would put three gallons of scallops into a five-gallon tub, add two gallons of water, put on the head and deliver to the shipper. When the shipment reached its destination, the tub contained five gallons of large dry scallops. This type of adulteration is rare today. Oysters and the soft shell clam require a wash after shucking, but if washed too long, the product is characterized as soaked. The oyster business is "big business" of an interstate nature and as such is subject to the scrutiny of the Federal officials, of the officials of the State of production, who naturally do not care for any criticism of a product of their own production, and also of the officials of the State where the oysters are to be consumed. This scrutiny should reduce adulteration to the irreducible minimum, yet the notices of judgment under the Federal law occasionally report the results of seizures of oysters adulterated by the addition of water.

The soft shell clam is a product of the coastal waters of Rhode Island, Massachusetts, New Hampshire, Maine, and the Maritime Provinces, but the business is small compared with the oyster business. There is a distinction between washing and soaking. A certain amount of water is absorbed during the washing process, but if the clams are allowed to remain in the wash water there is a greater absorption of water together with a loss of some of the water soluble food material which is removed by the water. The washing of shucked clams is essential and, therefore, adulteration cannot begin until after a suitable washing period. The washed clams then become a manufactured article different from the clams in the shell. It is, in many instances, a difficult matter to state the exact point at which washing ceases and soaking begins.

SUMMARY OF ANALYSES OF 63 SAMPLES OF SOAKED SOFT SHELLED CLAMS

No. of samples	*Average solids*	*Average water soluble solids*
	%	%
11	15.4	7.1
14	14.5	6.5
19	13.4	6.0
5	12.6	5.2
4	11.8	5.0

The preceding table shows the analyses of fifty-three samples of soaked clams. Each figure represents the results of the average of the samples with 15, 14, 13, 12 and 11 per cent solids respectively.

Elmer R. Tobey has published the analyses of 203 samples of shucked and washed clams. He states: "Clams

opened under proper conditions, washed but not soaked, show an analysis of free liquids not more than ten per cent, solids on the drained meats not less than eighteen per cent." His analyses show, on the whole, clams of fairly high quality. There were but fifteen samples with more than ten per cent free liquids, although seventy-nine had solids less than eighteen per cent. If both figures are used to prove soaking, only eleven samples were soaked. If the free liquor is entirely drained from soaked clams, the drained meat would nevertheless retain water absorbed during the soaking process.

Figure 3 from Tobey's data shows the relation between the average free liquor and the average solids on the drained meats. The samples with the highest free liquor also had a high solid content. Possibly the liquor was the natural liquor rather than that obtained by washing.

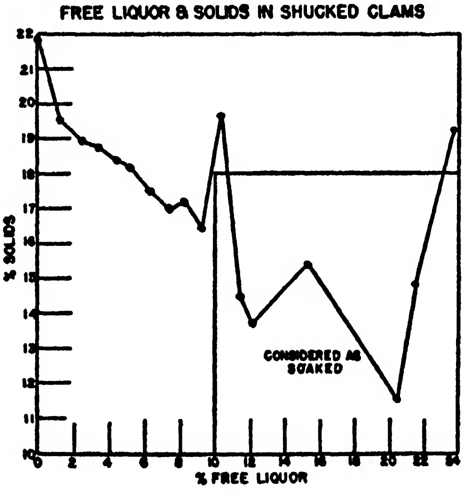


FIG. 3.

Vinegar. Vinegar is a solution of acetic acid produced by the fermentation of alcohol. The acetic acid content of vinegar depends upon the alcoholic content of the cider or wine from which it was made, together with the efficiency of the fermentation. The federal standard for vinegar is not less than four per cent acetic acid, and this standard is, either by law or regulation, the standard of practically all the states Occasionally vinegar can be fermented to an acetic acid content of nearly six per cent. The standards and the law permit dilution to four per cent, provided the package is labeled "Diluted to Legal Strength," or words to that effect. The average vinegar sold at retail is thus diluted and is so labeled. If the standard were higher, say 4.5 per cent, which was formerly the standard of the State of Massachusetts, there would be a saving in freight which in the long run would be considerable, but would make a saving to the consumer of only a few cents per year.

A beverage called coffee Owing to war conditions, transportation by water of food and other materials has become a somewhat hazardous occupation, resulting in a shortage of many articles of daily use, of which coffee is one. When the consumer prior to rationing was too often deprived of his daily cups of coffee in his home, he found that he could get "coffee" at the restaurants and acted accordingly. Because of this anomaly, an investigation was made which showed that many restaurants were not serving coffee, but a beverage made from a mixture of coffee, roasted chicory, peas, pea hulls, wheat, and so on. Investigation showed that the coffee dealers had sold the adulterated material, properly labeled and billed as such, but the restaurateur was willing, and even anxious, to sell the beverage as pure coffee and often urged his patrons to have some coffee when such had not been ordered.

The pure beverage coffee first purchased was from thirteen different restaurants, and it had a concentration of from 0.5 to 1.4 grams of solids per hundred cubic centimeters, averaging 1.02. The next twenty-six samples, made from pure coffee and collected a short

time later, varied in concentration from 0.5 to 1.2 grams of solids per hundred cubic centimeters, with an average of 0.8 grams per hundred cubic centimeters. This represents a dilution with water to an extent of nearly twenty per cent.

Flavoring extracts. Flavoring extracts, such as lemon, orange, peppermint, wintergreen and a few others, are made by dissolving the necessary quantity of the essential oil in ninety-five per cent alcohol. The greater cost is often in the alcohol, which varies with the internal revenue tax. These articles were often adulterated by the addition of three or four volumes of water. This precipitated the oil which was removed by filtration after the addition of an absorbent, such as magnesia. This product has been in part legalized under the name of terpeneless extract, and standards for the concentration of citral have been made for terpeneless lemon and terpeneless orange extracts. They are decidedly inferior to the undiluted extracts.

Alcoholic beverages. Alcoholic beverages are so constituted that watering can be practiced sometimes to the preference, as well as to the welfare, of the consumer.

Distilled liquor is popularly supposed to be 100 proof, that is, to contain fifty per cent alcohol, although the popular preference is for the blended whiskey of 90 proof, or forty-five per cent alcohol.

Between 1895 and 1901, the Massachusetts Department of Public Health examined eighty-two samples of whiskey obtained from drug stores, all of which were supposed to conform to the requirements of the United States Pharmacopoeia. Of these samples, 29.3 per cent contained less, and 8.5 per cent contained more, alcohol than the pharmacopoeia prescribed for whiskey.

In 1904, the Police Commissioner of Boston submitted sixty samples of whiskey. The analyses disclosed the fact that the worst ingredient from the health standpoint was alcohol, and that the most extensive adulterant was water. Seventy-three per cent of this whiskey contained added water, 66.3 per cent to an extent of 6.5 per cent or more, and 5 per cent to an extent of 29 per cent or more.

In 1923, the police departments of the State submitted 3,746 samples of distilled liquor. Here again it was found that the most injurious ingredient was alcohol, and the greatest adulterant was water. Of these samples, 67 per cent contained added water, 40 per cent to an extent of 9.5 per cent or more; 20 per cent to an extent of 25 per cent or more; and 7 per cent to an extent of 30 per cent or more.

Samples of whiskey recently purchased from saloons in Massachusetts were found, upon examination, to vary from 79.4 to 86.2 proof, averaging 82 proof. The United States Pharmacopoeia and the bottled in bond whiskey is required to be 100 proof, but the pre-prohibition blends were usually 90 proof. These recent samples, if based upon a standard of 100 proof, contained from 13 8 to 20.6 per cent added water, but if based upon a standard of 90 proof, contained from 2.7 to 11.8 per cent added water.

Drugs

Tincture of ginger. Tincture of ginger prepared as described in the United States Pharmacopoeia contains in each liter the alcohol soluble materials from 200 grams of ginger dissolved in ninety per cent alcohol. This substance has been used for years by many people solely because of its alcohol content. In order to furnish a material more suitable for beverage purposes, it was a common practice to manufacture a tincture of ginger of lower alcoholic content. This diluted material often was put up in very attractive bottles, some of which were labeled, "Picnic Flasks," and was frequently sold in Massachusetts towns

where the citizens had voted not to grant licenses for the sale of intoxicating liquor.

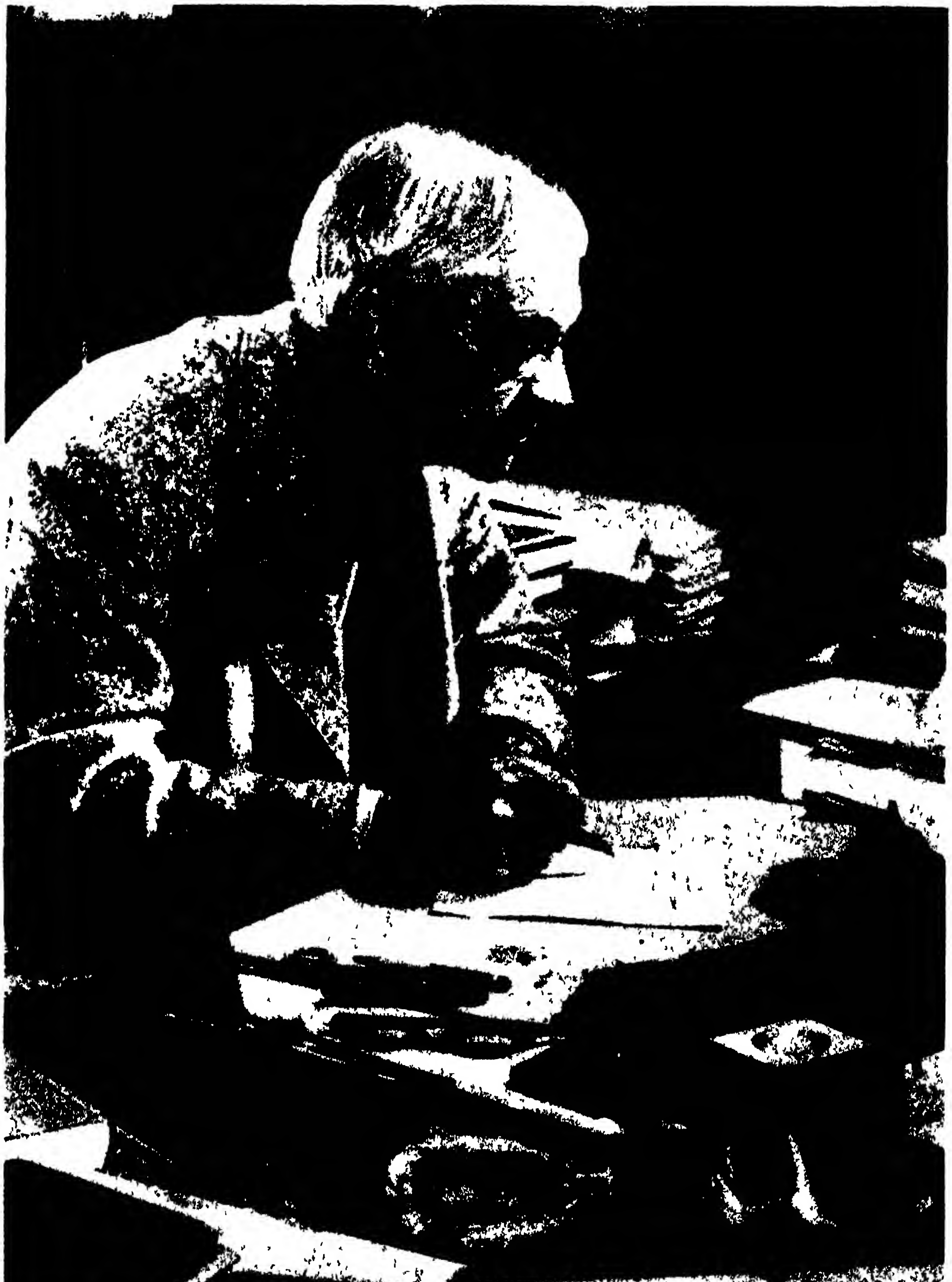
Double strength ginger extract containing the full complement of alcohol, even if more or less deficient in ginger resins, appeared during the prohibition era as the result of a Treasury Department's decision The human animal soon demonstrated his ability to drink undiluted double strength tincture of ginger. The courts have recognized tincture of ginger as being an intoxicating liquor, within the meaning of the laws of Massachusetts

Spirits and tinctures Some of the foreign pharmacopoeias prescribe 80 per cent alcohol as well as 95 per cent alcohol in making certain spirits and tinctures For example, the French Pharmacopoeia prescribes 90 per cent alcohol for making spirit of peppermint, while the United States Pharmacopoeia prescribes 95 per cent Quite often the alcohol-soluble substance will dissolve as readily in 80 per cent alcohol as in 95 per cent alcohol, and the tincture or spirit so prepared will be as good in therapeutic activity as if made from the stronger alcohol. Spirit of camphor, up to the requirements in camphor content but made with 75 per cent instead of 95 per cent alcohol, was occasionally sold in Massachusetts twenty-five years ago There was a saving in tax, a reduction in cost, but no reduction in the active drug

New and Unusual Uses of Water as an Adulterant. Notices of judgment published by the United States Food Administration during the past few years have shown new methods of using water as an adulterant. For example, there have been several seizures of poultry into which water has been injected so as to increase its weight. There have been seizures of canned cat and dog foods. One such shipment was labeled to indicate that it contained significant amounts of meat, meat products, and carrots Adulteration was alleged in that valuable constituents, that is, meat, meat products, and carrots, had been wholly or in part omitted from the article and water added. There have been seizures of sauerkraut juice containing, in one instance, only about half the minimum amount of lactic acid that properly made sauerkraut juice should contain, alleging that water had been substituted wholly or in part for sauerkraut juice.

Possible Adulteration by Water Many complaints have been received of alleged adulteration of sweet cider by the addition of water Although these complaints have been investigated, sufficient evidence has never been obtained to warrant further procedure Manufacturers of broken-out eggs have complained that their competitors have been adding water to broken-out egg whites Investigation showed normal composition in each instance There are, however, a few untouched fields worthy of study and investigation, such as tomato juice and orange juice (not orangeade), served by hotels and restaurants.

Numerical Standards. The elimination of water as an adulterant is, to some extent, augmented by the establishment of numerical standards Examples are: the fat standard for butter; the standard for total solids, or solids exclusive of fat, for milk, maple syrup to be concentrated to a weight of 11 pounds per gallon; bread not more than 38 per cent moisture; macaroni and similar articles not more than 13 per cent moisture; dried milk not more than 5 per cent moisture.



WILLIAM LYON PHELPS (1865–1943)

WILLIAM LYON PHELPS, 1865–1943

"How good is man's life, the mere living!
how fit to employ
All the heart and the soul and the senses
forever in joy"

Browning. *Saul.*

FOR half a century, William Lyon Phelps has been a familiar and beloved figure on the academic campus and on the American scene He has found both fields alike open and challenging To both he has brought a glad and vital interpretation of literature and life His conception of the rights to individual life, liberty, and the pursuit of happiness has been fulfilled in terms not of Ivory Towers and Elysian Fields but of the active and abundant life

Ever since he first began to teach English literature at Yale in 1892, and presently gave his first public lectures, his personal magnetism has attracted followers and friends beyond number The unfolding story of his instant and constant success in classroom and on public platform has become proverbial His direct and persuasive influence in enhancing knowledge and appreciation of literature and the fine arts generally has been widely felt and recognized Universities and colleges throughout the country have delighted to honor him with distinctions and titles extraordinary in number and diversity But no less manifest have been his clear and constant titles to popular esteem and to personal affection that far exceeded academic limits.

The range of his interests and the warmth of his sympathies brought him close to the minds and hearts of listeners of all types and tastes. Whether in the academic robe of his accustomed office as Public Orator at University Commencements, or in the informal light homespun so familiar to those who thronged his popular lectures, he was ever at home with his subject and with his audience. None knew better how to establish quick accord between speaker and hearer. Ready wit and natural friendliness of tone and manner counted in first impressions as certainly as infectious enthusiasm and unfeigned sincerity confirmed and strengthened them. With him the spoken word took on warmth and color and colloquial charm

His conversational manner, in turn, encouraged the ready give-and-take of the question-and-answer period which he early added to his literary lectures The printed prospectus of his first considerable series of public lectures in 1897 is significantly entitled *A Course of Reading in Nineteenth Century Poetry.* Each lecture is set forth in main outlines and with full accompanying list of reading The final note is characteristic: "The members should do the reading before each lecture, making notes of anything they wish to have explained or discussed, and it is earnestly hoped that either during or after each lecture everyone will feel perfectly free to ask questions, make suggestions, or oppose the lecturer's opinions Questions that require a fuller discussion may be submitted or mailed to Professor Phelps, and they will be answered for the benefit of the class at the beginning of the following lecture." A born teacher, he was free from formalism and dogmatism. To him teaching was not so much a profession as a passion. He ardently coveted for others his own insatiable thirst for reading and in rare measure he gave to others generous guidance and the sense of comradeship in novel and rewarding

adventures in the world of men and of books.

As within the college classroom Professor Phelps made the spoken word the quick medium of intimate accord with his students, so in a steady stream of books and periodical articles, he made the written word a flexible means of quickening the perceptions and sympathies of his readers. "My task which I am trying to achieve," wrote Joseph Conrad in defining his aim as creative artist, "is, by the power of the written word to make you hear, to make you feel—it is, before all, to make you *see*. That—and no more—and it is everything" Conrad's creed does not lose meaning, if applied to the like, though lesser, art of re-creative interpretation of creative literature Of such revivifying power Professor Phelps was a lifelong exemplar, for he could unstop deaf ears and open blind eyes

As readily as he moved his hearers to participate in classroom or public forum discussions, did he stir his readers to respond with written queries and comments Month by month, for many years, his section of *Scribner's Magazine*, entitled "As I Like It," reflected far more than the personal tastes and opinions of its author Under his guidance it became a clearing-house for the interchange of diverse views and for mutual enjoyment of the interplay of many minds. He himself cultivated and personified the hospitable and yet independent spirit.

In academic parlance, the special field of Professor Phelps was *Litterae Humaniores* Of his many doctoral titles none fitted him so well as that of Doctor of Humane Letters. He had, indeed, some qualities in common with the scientist—eager intellectual curiosity, courage in daring experiments, and zest for new discoveries. He was a pioneer in various fields of study and teaching, as when he opened revolutionary courses in contemporary fiction and drama. But he was a modernist with deep reverence for the inheritance of the past. His final addresses, one to the members of a Yale Residential College, another to the Baccalaureate audience at New York University, were alike arresting interpretations of the undying values of the classics of literature as revealed in Homer and Shakespeare. From the outset to the end, William Lyon Phelps remained an interpreter who could reconcile warring impulses and elements through single-minded and wholehearted faith in the humanities of life and learning

George H. Nettleton
Lampson Professor of English, Emeritus,
Yale University

THE PROGRESS OF SCIENCE

CONCENTRATIONS OF VITAMIN A, CAROTENE, AND XANTHOPHYLL IN NORMAL HUMAN BLOOD

EVERYONE realizes that the provision of suitable food for the armed forces and civilians at home is one of the most important factors in winning the war. Since World War I, we have learned that in addition to sufficient amounts of fats, proteins, carbohydrates (sugar, starch) and minerals, the diet must also include vitamins.

In our laboratory, we have been especially interested in studying vitamin A. This vitamin is essential for the growth and well-being of man and prevents the disease of the eyes known as xerophthalmia. This vitamin is found in such foods as butter, milk, eggs, liver and fish liver oils. In the first World War, many children in Denmark became permanently blind because the butter produced in Denmark was exported to Germany, and only the skim milk, from which the vitamin A had been removed, was left for the children to drink.

For some years investigators believed that vitamin A was present in the blood of man and animals, but this was difficult to prove because the amount in the blood is very small and because it is associated with large quantities of fat. Recently we have been able to establish the presence of vitamin A in human blood by adsorbing the vitamin on magnesium oxide and then determining its spectrophotometric absorption curve and the curve of its reaction product with the antimony trichloride reagent. This reagent gives a characteristic bright blue color with solutions of vitamin A.

While vitamin A is present normally in the blood of man and animals, the carotinoid pigments (carotene and xanthophyll) are found in the blood of only a few species, notably man, monkey, cattle and fowl. In man, vitamin A, carotene, and xanthophyll are found in the fluid part of the blood, or plasma, and not in the red cells. Vitamin A is an alcohol. Most of the vitamin A in the blood is in the free or alcohol form, but it is stored in the liver mainly esterified with fatty acids.

The yellow pigment carotene, or provitamin A, is changed in the body into vitamin A. It is found in carrots, yellow wax beans, orange juice, apricots, and many vegetables and fruits. Xanthophyll is another yellow pigment found in many vegetables, but we do not know of what use it is in human nutrition. Some of the beautiful colors of autumn leaves are due to carotene and xanthophyll.

Sometimes a person eats so many fruits and vegetables that his skin becomes quite yellow from these carotinoid pigments and the person is said to have "carotinemia." This is a harmless condition and the yellow color fades away when less of these foods is eaten.

Chemical methods have been developed for the determination of vitamin A, carotene, and xanthophyll in the blood and tissues of man and animals. In a recent study we have determined the concentrations of vitamin A, carotene, and xanthophyll in the blood of seven normal women and fourteen normal men the first of each month for the year August 1, 1942, to July 1, 1943. These subjects, who were eating a good average diet, were professors, interns, medical students and persons employed in the laboratories and offices of the University of Rochester Medical School. The concentrations of carotene and xanthophyll in the plasma were greatest during the autumn months, especially October, when fresh fruits and vegetables were plentiful and inexpensive. The

pigments were lowest in the late spring, in April and early May, when fresh fruits and vegetables were difficult to obtain The pigments were probably lower than usual this year because the canned pigmented vegetables, such as peas, yellow corn and string beans, were rationed and people had to eat more of the colorless vegetables, such as white turnips, cabbage and onions, than they usually do. The vegetables being raised in hundreds of thousands of Victory Gardens will help greatly in supplying the carotene, or provitamin A, needed by everyone.

Surprisingly enough, the concentration of vitamin A in the blood of our subjects remained remarkably constant during the different seasons; that is, the vitamin A seemed to be independent of the amount of its provitamin, carotene, which was in the blood We know, however, that in normal persons there is a large store of vitamin A in the liver It may be that the healthy body is able to draw upon this store when vitamin A is lacking in the food, and so keep the vitamin A of the blood at the needed constant level throughout the year

In the group of people studied, each person tended to keep his or her same relative position throughout the year; that is, a certain individual almost always had the highest levels of carotene, xanthophyll, and vitamin A, while another almost always had the lowest values Some subjects had high vitamin A values and low pigment values, while other subjects had high pigments but low vitamin A The differences in these values between our subjects seemed to be due to differences in the diets eaten, in the amount of pigments and vitamin A absorbed through the intestinal tract, and in the rate at which carotene was changed into vitamin A in the body.

The men had more vitamin A in their blood than the women. The average vitamin A for the year for one man was 224 International Units per 100 ml. of plasma, while the average for the group was 137 Units. This subject, in addition to eating an excellent diet, was accustomed to have a glass of sherry or some other alcoholic beverage with his dinner each night. We have shown that in man and dogs, vitamin A is mobilized from the liver into the blood by alcohol, and this fact may have been a partial explanation of this subject's high vitamin A.

One woman subject had very high carotinoid values, but the lowest average vitamin A—97 Units—of the group. We thought she was not utilizing or converting her carotene into vitamin A in a normal manner and that medication with thyroid might be indicated in her case

Some of the subjects suffered occasionally from infections such as colds and the new disease, pneumonitis During the acute stage of the illness, the vitamin A in the blood promptly fell to a low level, but after recovery soon returned to the normal value for that person Indeed, fever of any kind, such as that associated with scarlet fever, pneumonia and tuberculosis, causes a rapid decrease of vitamin A and a slower decrease of carotene in the plasma This suggests that during long continued illnesses, extra vitamin A should be given the patient

However, in some diseases, such as those of the kidney, of the thyroid gland and diabetes, the vitamin A or pigments of the blood may be much greater than normal. In other diseases, such as those of the liver and intestinal tract, the patient may not be able to absorb vitamin A when given by mouth and it is desirable to inject the vitamin directly into the muscles

A study of the vitamin A and carotinoid pigments of the blood is of aid in improving the nutrition of man and in diagnosing and treating his diseases.

S W. Clausen and A. B. McCoord

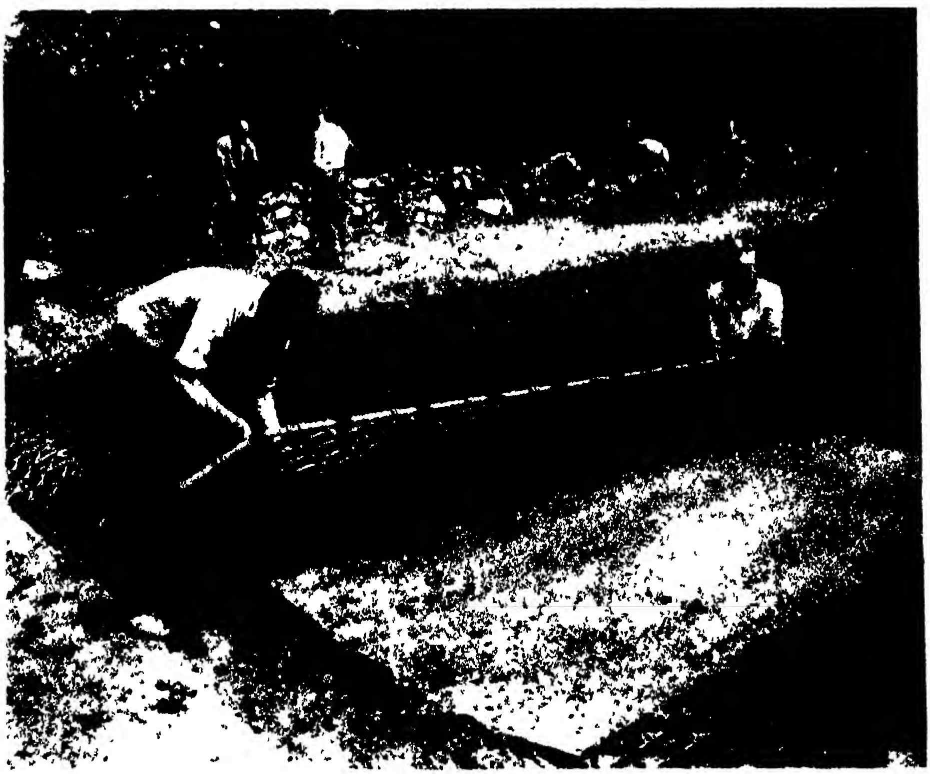
HIGHWAYS OF STEEL

THE steel highway may be among the numerous technological inventions made for the battlefront that will become part of the fabric of everyday life in the post-war era.

Our armed forces have found the portable emergency landing mat of incalculable value, particularly in the jungle terrain of the Solomons, on the sand beaches of the Mediterranean and on the frozen land of the Aleutians. Out of these easily laid and hard wearing steel mats came the idea of the prefabricated steel highway which was recently projected by the Irving Subway Grating Company of Long Island City and by the township of Darien, Connecticut. As a joint experiment to prove the practicability of entire roads of steel grid, a steel roadway strip, 48 feet long and 22 feet wide, was constructed as a section in a highway where it will be put to test under normal passenger and truck traffic conditions. If it proves durable under such heavy wear it may become the prototype for a network of steel secondary roads throughout the Western Hemisphere.

The technique employed for the experimental installation involves attaching steel grating panels, each 2 feet by 12½ feet, filling the mesh with ordinary construction sand, and applying a coating of road oil. The mats are fastened together at the ends for stability, anchorage is effected by bent ends.

Steel grating of a similar type is now used as bridge decking and has proved to be remarkably non-skid in character. Steel surfacing of truck roadways connected with factory plants are also being



LAYING STEEL GRATING MATS FOR HIGHWAY TEST AT DARIEN, CONN

FILLING INTERSTICES WITH SAND BEFORE COATING WITH ROAD OIL

used and these are said to have already qualified for durability.

The steel highway should be particularly useful in localities where the roads are frequently washed out or otherwise impaired by weather conditions or excessive wear and tear Its model, the emergency landing mat for airplanes—because it is easily and quickly laid, portable, and affords excellent traction—is playing a crucial part in the war.

The steel mats may be envisioned as affording emergency roadways to be used in rushing aid to areas devastated by the war, by storm or flood, and in supplying paths over precipitous mountains, rain-soaked jungles or frozen tundra. The greatly increased steel capacity enforced by wartime needs will doubtless result in many still undreamed of uses of this vital material Perhaps the new steel mats will provide one of the means necessary to maintain the difficult and chronically ailing passages of the Burma Road or to complete the Pan-American Highway, thus physically uniting the good neighbors of both Americas.

M. D.

THE NEW DIVISION OF ELECTRON AND ION OPTICS IN THE AMERICAN PHYSICAL SOCIETY

THE natural tendency of any growing science is to subdivide itself. The special topics developed at first by a few become the occupations of many workers, who find their respective specialties becoming so rich in knowledge and opportunity as to claim a steadily rising fraction of their energy and time. One of

the duties of a scientific society is to combat this tendency and to maintain the unity of its science as long as possible. This may seem a singular introduction to the statement that the American Physical Society, which for nearly fifty years has subsisted as a single body, has now commenced to organize a Division of Electron and Ion Optics

Paradoxical as it may sound, this step is regarded by the officers and the Council of the Society as a step in the direction of unity and not in that of disintegration. The policy is not to deny the trend towards specialization but to keep the inevitable subdivisions within the framework of the Society so that those who specialize in them may continue to hold their meetings and their publications (to some extent at least) in common, and may continue to regard themselves and to be regarded as being physicists and members of a society of physicists This policy is closely allied with that of increasing the part which industrial and applied physicists take in the meetings and other activities of the Physical Society: an important matter, now that the proportion of physicists engaged in industry and in the "borderline fields" is rapidly rising

The opportunity for forming divisions within the American Physical Society was given several years ago by an amendment to the Constitution of the Society. Advantage has now been taken of it, owing in the main to the initiative of L. Marton of Stanford University, who undertook the requisite preliminary step of formulating a petition to the Council and winning the signatures of numerous members. The Division of Electron and Ion Optics is now in process of organization, and will probably make its debut as sponsor of a special program at one of the general meetings of the Society to be held during the coming winter and spring.

The following statement of the scope and object of the Division of Electron and Ion Optics has been prepared mainly by Dr Marton

"Electron and Ion Optics" is a relatively recent branch of physics. Some of its fundamental facts were known for a considerable time before its name was coined; but its proper history commences only with the last ten or fifteen years. During this recent period the optical analogies, existing between the behavior of a beam of light passing through refracting media and that of a beam of electrons passing through suitably shaped electric or magnetic fields, have been clearly recognized The discovery that electrons and ions can be focussed by radially symmetrical fields, that images can be produced by such fields and that the action of any field can be described in terms of geometrical optics, was startlingly new Such optical analogies helped in the better understanding of earlier observations, but much more than this, they started a very rapid development in a number of fields Already electron and ion optics comprises theoretical, experimental and applied branches. The task of the theoretical physicists is to calculate the path of electrons or ions in electric or magnetic fields, to calculate new combinations with reduced aberration, to develop the theory of such effects which enter into the operation of electron or ion optical devices (such as, for instance, electron and ion scattering, diffraction, etc) On the experimental side we can quote the investigation of electron or ion optical systems, the observation and measurement of the aberrations, and the design and practical realization of suitable fields. The work of the experimental electron optician toward newer and better systems very often overlaps with some problem of applied electron or ion optics.

The products of applied electron and ion optics are very manifold. A few of them have been widely publicized, such as the electron microscope, the cyclotron and other apparatus of transmutation,

many kinds of radio tubes and television apparatus. Other less widely publicized instruments are, however, very important in physical or other research; among these are mass spectrographs, cathode ray tubes and oscillographs, and electron diffraction apparatus All such instruments have in common the characteristic that in them electrons or ions are accelerated, and the paths of these are modified by means of electric or magnetic fields in such a way that some kind of "focussing" of the beam is achieved, thus justifying the name "optics"

The field of the newly formed Division of Electron and Ion Optics of the American Physical Society is defined to comprise all theories and all apparatus involving the forming, directing, shaping and focussing of beams of electrons and ions This definition is intended to make clear that the Division is not restricted to any special applications (such as, for instance, electron microscopy alone). Presumably the intention has been realized, as nearly five hundred members of the Society have already enrolled as members of the Division Though the scope of the Division is thus carefully defined, it is not intended in the least to exclude any member of the Society who is interested enough to join; and nothing will preclude anyone who has joined this Division from joining any others which may later be formed. It should be stressed, also, that the function of the new Division is not a duplication of that of any already existing Society devoted to a special field of applied electron optics, but a grouping of those who are interested in the physics of electron-optical and ion-optical apparatus

KARL K DARROW

NATIONAL CONSUMERS FOOD CONFERENCE AT CLEVELAND

THE National Consumers Food Conference in Cleveland, Ohio, October 27 and 28, 1943, was a significant and interesting move on the part of some eighty large national organizations of consumers to inform themselves on international and domestic food distribution and production problems The significant point is that the Conference was not planned, promoted or controlled by any government agency or commercial interest. Instead, it was a manifestation on the part of a wide variety of citizens' groups that it is time for the consumer to take a hand in setting the food policy which affects him so profoundly.

The Conference was sponsored by Food For Freedom, Inc., a voluntary non-partisan committee of private individuals, under the chairmanship of Mrs. Dwight W. Morrow, representing a cross section of citizens' organizations It was initiated by a timid letter of inquiry which went to organizations representing national education groups and university women, to church, labor and racial organizations, to settlements, and to other civic and professional associations. This letter served as a preliminary feeler to see if the general public was interested in having a National Consumers Food Conference. For the most part, the response from the officers of these organizations was so enthusiastic that Food For Freedom decided to go ahead with plans for the Conference with the advice and cooperation of a "steering committee" composed of representatives of the most interested of these organizations.

The Conference was set up in a series of seven round tables to consider respectively, the following questions How can we really hold food prices down? How well is our food distribution working? How is the war worker feeding himself and his family? How can we make the best use of our food in wartime and after the war? How can we step up home production and conservation of food? Can the consumer help to get

maximum production? What can we do to help supply the food needs of our allies and of liberated peoples?

The final recommendations from the Round Tables were given to all the delegates at a general session and were to be used as a basis for individual action by each national organization as it sees fit In order that the discussions might attain the fullest public value, the Conference was so arranged that no Round Table chairman or delegates were federal or state officials or representatives of large commercial food trade interests As Dr William Allan Neilson, Chairman of the Board of Food For Freedom, said while presiding at the Mass Meeting at the Cleveland Public Auditorium·

Such an educational campaign as we have in mind cannot best be carried on by any government agency because of the understandable limitations controlling such agencies nor can this type of educational activity squarely face the issue presented by the critical food situation abroad if it is attempted by a group under the domination of the food trade interests

The importance of free discussion on the part of free citizens was recognized as one of the precious attributes of a free country which should be constantly exercised in the face of a wartime tendency to sit back and "let the government decide" without an expression on the part of the people. Government experts were invited to attend the conference only as consultants and were called upon for information but did not dominate or control the discussions In this manner it was hoped that the reports would reflect the thinking of the representatives of the eighty national organizations present and that the recommendations made would be in the larger public interest

Some passages in the reports are of special significance, such as the following by Miss Elizabeth Magee, Secretary of the National Consumers League:

Consumers can do much, which they are not now doing, to promote effective prosecution of the war and the laying of the foundation for a just and lasting peace by demanding maximum production and total use of all resources, both material and human. To give lasting meaning to the aims for which this war is being fought, they should demand that the adequate production and total use of all resources be carried over into the peace period. Within agriculture, this should result in abundant production and total use of farm resources Because it offers the best hope of maximum production and the surest base for economic, social and political stability and health, consumers should support legislation and other efforts to make possible the existence of family type farming as the pattern of American agriculture

One central theme permeated the seven Conference Round Tables and the speeches of Vice-President Wallace, Dr. Neilson, Mrs Morrow, Dr Theodore Schultz of the University of Chicago, Morris Rosenthal, former Deputy Director of the Board of Economic Warfare, Leon Henderson, former OPA Administrator and General Chairman of the Conference, President James G Patton of the National Farmers Union, and Victor Reuther of the United Auto Workers That theme was also the conclusion of the United Nations Food Conference at Hot Springs, Virginia, namely, that in the years immediately ahead there is no possibility of producing too much food anywhere in the world and that, conversely, the need is extreme for swiftly turning acreage into essential food production wherever that acreage holds promise of a yield worth the effort

The Conference recommended at the final general session that Food For Freedom Inc, continue its work by carrying on a nation-wide study and educational campaign through a series of regional and local conferences patterned after the Cleveland Conference. It was recognized that such an undertaking is vitally needed to familiarize the people of this country with the role increased production and improved distribution of food can and must be made to play in building an enduring and democratic peace

FLORENCE R WYCKOFF

BOOKS ON SCIENCE

INTRODUCTION TO CELESTIAL NAVIGATION*

This *Primer of Celestial Navigation* by Dr. Favill is the kind of book desired by one who wishes to know something of the whys and wherefores as well as the technique of determining a position at sea or in the air from observations of the sun and stars. As stated in the introduction, Dr Favill fully appreciates that, with modern short-cut methods utilizing the Air Almanac and such convenient tables as Hydrographic Office Publications Number 214, anyone of ordinary intelligence can be quickly taught the procedures for observing altitude of the sun and stars and determining in a very few minutes therefrom his latitude and longitude. A student with an intelligent curiosity, however, may well have time enough at his disposal to ask many fundamental questions which this book will answer.

After an appropriate introduction, the author presents the fundamental astronomical concepts which underly the science and practice of navigation Since it is apparent from the contents of the book that the author acquired his proficiency in navigation as a pastime, he has an appreciation for some of the difficulties encountered by the student who undertakes the subject by himself without formal training in mathematics or science, and in general, his exposition of fundamental concepts is all that such a student could desire.

To avoid confusion in the main text, the author has relegated numerical problems to the end of the book A bibliography and a comprehensive index close the volume.

The book represents a fairly comprehensive introduction to celestial navigation and is a running commentary on the subject matter of the classic *American Practical Navigator* by Nathaniel Bowditch. It does not pretend to replace Bowditch nor does it include tables for the working of problems. These must be purchased separately from among those recommended. For the purpose of an accelerated course in navigation to meet the present war emergency, the book contains too much material and the presentation of so many methods would seem to be confusing rather than otherwise to the student whose time available for navigation is reduced to a minimum. The volume, however, should prove of interest to those desiring more knowledge of the art than is obtained from mastering short-cut methods in an emergency course The book contains 263 pages and many diagrams Its small dimensions commend it for accessibility and convenience. It is a useful addition to any nautical library.

HARLAN T STETSON

* *Primer of Celestial Navigation.* John Favill. 46 ill. xvii + 263 pp. 2nd edition. 1943. $2.00. Cornell Maritime

ELEMENTARY ELECTRONICS*

RAYMOND F. YATES is a prolific and deft writer of "popular science" in the quasi-engineering magazines that sell so well among non-college youth As editor of *Modern Mechanics and Inventions* he knows their technical tastes and limitations. He has catered to their avid need of self-education by a dozen books on radio, model boats, microscopy, model engines and trains, and the "art" of inventing. "Super-electricity" is another such book. Its sub-title is "What You Can Do in Electronics." It is, however, no textbook. It expounds the first principles with a few elementary diagrams, lists hundreds of industrial and commercial uses of electronics; advises the

* *Super-Electricity.* Raymond F. Yates. Ill. 165 pp. $2.00. September, 1942. New York. D. Appleton Century Company.

amateur on how to turn his hobby into a business and how to find a job, recommends practical books for home study; discusses electrical engineering training in colleges; and describes in some detail the excellent practical courses in electronics given by the R.C.A. Institutes. The high-school boy or girl who has a leaning toward radio can get a sketchy but realistic idea of what to do next from this book but will get no idea of the hard work and long study needed to achieve mastery of electronics

GERALD WENDT

THE HISTORY OF CONTAGION*

THE Four Horsemen of the Apocalypse once more ride roughshod over humanity. War's boon companions—Famine, Pestilence and Death—stalk the world today. Their victims are legion and the end is not yet. In most past conflicts, Pestilence brought more victims into the arms of Death than War itself Famine has already destroyed untold thousands Many others will follow this winter But Famine is earthbound and the dread agony of starvation spreads but very slowly compared to the winged speed of Pestilence. The menace of epidemic disease grows ever more acute as the war progresses The crisis of threat will come *after* the last gun is fired Then, once again, will occur free intercourse between peoples and the return homeward of many thousands of both conquerors and conquered. These hordes and legions of fight-weary civilians and soldiers will bring with them germs from far off places to populations unprotected by the immunization of long contact and often depleted by hunger, cold and fatigue. Fatigue will be much more apparent than now, when emotional drive spurs us on to hasten the day of victory and peace. But peace may bring devastating epidemics, unless enlightened social conscience and wise *scientific* administration effectively guard against infective diseases Wishful thinking, emotional platitudes, catchy slogans and candied ideals will not be sufficient; only stark realism can initiate adequate defense activities. Even here in our "isolated" United States there is a serious probability that troops returning from the tropics and the cesspool of Europe will bring with them infected insect vectors capable of spreading typhus, plague, yellow fever or malaria with speed greater than that of a prairie fire before a strong wind. Infected hosts, even if free of insect vectors, may well infect native American carriers of contagion

Such pandemics have been frequent and terrible aftermaths of war The need for effective defenses is imperative. Intelligent planning, research and application of existing knowledge presuppose a thorough understanding of the past, for history has a way of repeating itself. A foreground without a background is an incomplete picture A recent volume concerning the history of man's conquests over epidemic diseases, by Doctor Charles-Edward A Winslow, Lauder Professor of Public Health at Yale University, is both timely and useful. Professor Winslow has succeeded in writing an interesting, authoritative and accurate volume which is liberally documented. The major theme is the history of man's ideas concerning the causation of epidemic disease He traces the slow, painful evolution of etiologic thought from the earliest ideas of demonology, divine wrath, metaphysics, the early glimmerings of the concept of contagion and the first studies of epidemiology down through the epochal advances of Pasteur to modern knowledge. Three quarters of the four hundred pages are devoted to the eras preceding the advent of bacteriology.

More material dealing with the devel-

* *The Conquest of Epidemic Disease.* Charles-Edward A. Winslow. xii + 411 pp. 1943 $4.50. Princeton University Press.

opment of recent ideas of the etiology of epidemic diseases would be welcome to most readers. Professor Winslow has neglected to give his own significant contributions to epidemiology and sanitary science sufficient recognition As a clinician, long concerned with individuals rather than with the "wholesale" attitude of Public Health, the reviewer regrets that there is not greater emphasis upon the important elements of individual resistance, relative immunity and individual health in the spread of epidemic diseases This, however, may be a question of personal prejudice, for it is recognized that there are many who do not consider these important factors

The Preface reveals that the author intentionally limited his discussion to the history of ideas of causation of epidemic disease, in the hope that the story of epidemiological thinking may throw light upon the pitfalls, blind bypaths and errors of scientific analysis in other fields. The advances of bacteriology have been magnificent and the benefits to mankind enormous Nevertheless, in spite of the immense progress predicated upon the concepts of bacteriology, prolonged overemphasis of the rôle of the germ has, in some respects, retarded scientific development The idea of specificity of the invading organism in the causation of specific diseases blinded many to the fact that disease occurs only when the germ finds haven in a vulnerable host A seed without congenial soil does not produce Causation is always a combination of multiple factors, which are clearly divisible into three categories: (1) predisposing, (2) provoking and (3) perpetuating influences. The infective agent is but one of these; study of the other factors has been badly handicapped by the asymmetric interest in bacterial and other parasites. Professor Winslow is one of the very few teachers of Public Health who openly recognize the limitations of the bacteriologic approach, particularly in considering future progress.

The book is highly recommended as a scholarly and most interesting volume. All who read it will profit thereby

EDWARD J. STIEGLITZ

HANDBOOK OF PSYCHIATRY*

THIS volume, as its name suggests, aims to present the subject-matter of psychiatry in concise and simple terms In this aim it succeeds in substantial measure Intended primarily for medical students, the book is also prepared for all "whose work brings them in contact with mentally disturbed persons." Certainly the nurse and social worker can use it effectively, as can the college student of psychology

The descriptions of the various forms of mental disorder are simply presented, without much discussion of the mechanisms involved In general, the statements are accurate, except, perhaps, that the legal experience of the senior author crops out in his emphasis on the criminality of the psychopath and on the "drift toward crime" of the mental defective. With reference to the war psychoneuroses, too, one may question the need of an emotionally traumatic experience as the precipitating factor; too many cases are developing in our training camps to make that thesis hold!

The concluding chapters, particularly "Principles of Psychiatric Therapy," might be read with profit by everyone who has a mental patient in the family. A good index is provided, and a substantial bibliographical list follows each chapter.

The authors have presented information of value in condensed and readable form. The volume should have a good sale.

WINFRED OVERHOLSER

* *A Handbook of Psychiatry.* P. M. Lichtenstein and S. M. Small. 330 pp. 1943. $3.50. W. W. Norton.

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